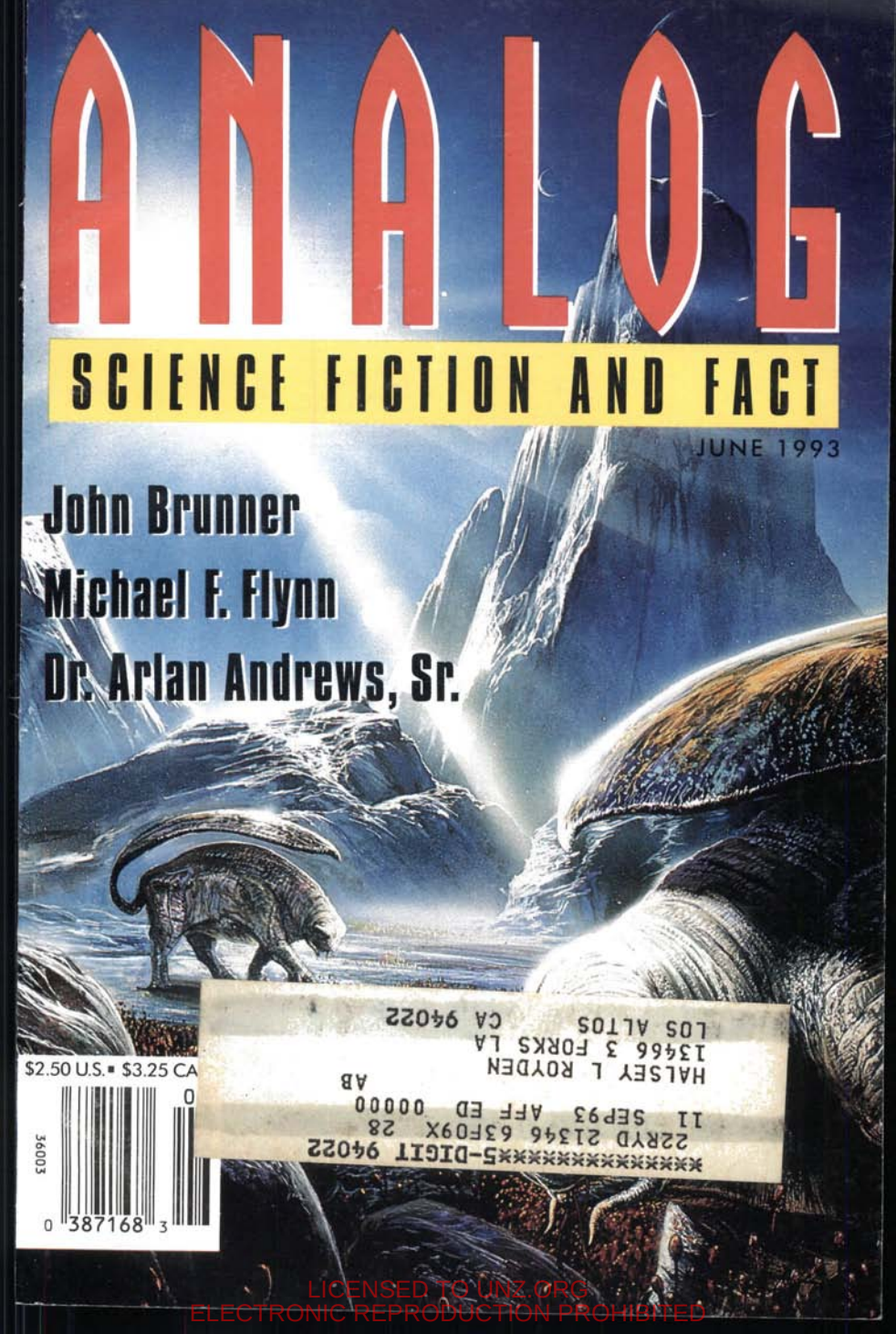

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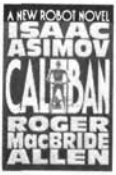

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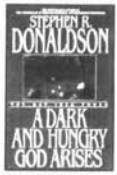

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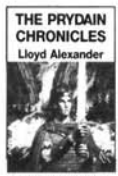

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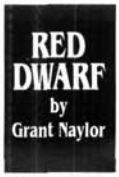

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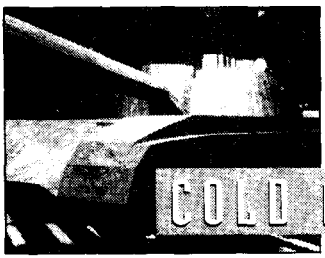

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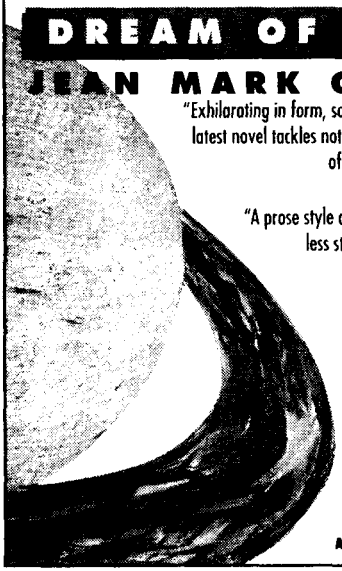

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EDITORIAL Stanley Schmidt

CROSSTALK

One of the rites of passage aspiring scientists must go through as part of graduate school is the thesis defense. Having completed a research project and written it up in a thesis, the student must then publicly "defend" his or her work by presenting it orally and submitting to on-the-spot cross-examination by a committee of professionals. Typically most members of the examining committee are specialists in the same general area as the student and his advisor—say, physics or chemistry—but one is an "outsider" invited in from some fairly distant discipline.

My thesis was in physics. The outsider on my committee was a metallurgist, which made a certain amount of sense because my research had involved making high-quality samples of certain intermetallic compounds. I had, in fact, briefly visited this metallurgist on one occasion to borrow a piece of equipment I needed to make those samples. But he managed to provide one of the more nerve-wracking moments in my defense ritual by asking a very simple and, in retrospect, obvious question. When I described the techniques I had used in preparing some of my samples, he said, "But there's an easier and better way that any metallurgist knows. Why didn't you ask me first?"

And I thought—and have thought again, many times since—*why indeed?*

The reason, I think, is simple, subtle, and insidious. Nobody ever told me *not* to ask a metallurgist's advice on how to do the metallurgy incidental to my physics, but nobody ever suggested that I *should*, either. And the pervasive intellectual climate of the university, which I fear was and remains fairly typical, tacitly discouraged it. Departments tended to be very self-contained. The members of one talked to their colleagues in the same department frequently, both in their labs and offices and at department parties (such as the ones following thesis defenses), but seldom to those in *other* departments. I'm not sure physicists often really thought of biologists or historians as colleagues. I didn't even know any metallurgists until my advisor re-

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ferred me to one with the equipment I needed to use. I had the strong impression that taking up the time of people in other departments was an imposition and a last resort, to be used only after I had exhausted my abilities to do everything on my own.

Looking back, I'm not at all sure how many people, in any department, actually felt that way. But I feel quite sure that to the extent that it's real, it's a counterproductive attitude. How many other useful ideas could I or my fellow physicists have picked up from the metallurgists, the chemists, the engineers, or even the architects? How much could they have learned from us, or from each other?

My advisors did many good things for me, but I wish they had made a more active effort to make sure I did *not* feel that way about "crosstalk," or let myself be put off by the belief that others did. I'd like to see education at all levels, and especially grad school, include a very explicit encouragement of the belief that intellectual progress depends heavily on cross-fertilization, and that practitioners of different disciplines can and should learn a lot from each other. As a corollary to that, to make it work, I would have liked to see the university provide more occasions, such as *inter*departmental parties, to make sure everybody met lots of people from other parts of the campus. You're much more likely to consult somebody if you know they exist, and have some idea of what they're doing, than if you don't.

In electronics, crosstalk is usually undesirable. It means things like hearing part of somebody else's telephone conversation while you're trying to have your own, because of induction between neighboring telephone circuits; or the signal on one stereo channel spilling onto the other. Perhaps, in some circles, this connotation has something to do with the generally unfavorable view of other forms of "crosstalk"—it's seen as a sort of contamination of something that the "insiders" would rather keep pure. That can't be the whole explanation, though; relatively few people are familiar with the shoptalk of communication technologies.

And, of course, *some* interdisciplinary communication does occur. Chemists and geologists have long used x-ray diffraction, borrowed from physics; and medicine has recently made big strides by appropriating things like magnetic resonance im-

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aging and positron emission tomography. Archaeology, by its nature, depends heavily on input from geologists, chemists, botanists, and assorted other specialists. But the well-known examples like PET and CAT scans tend to be cases where a few people in one field somehow picked up an idea from another, recognized that it had obvious and far-reaching value to their own discipline, and began spreading it among their own colleagues.

Those cases are relatively rare. How many more connections are being missed because of the scarcity of routine, casual sharing of ideas among people in different fields?

Most writers can tell you cases from their own experience in which they long had two ideas, each of which seemed full of story potential but never seemed to go anywhere until the author thought of *combining* the two—and then the combination seemed to "ignite" and generate a story almost spontaneously. Often the two ideas occurred at different times to the same author, but sometimes what's needed is the bringing together of the right *two* authors.

One of the most popular series of stories we've published in *Analog* was that about Valentina, by Joseph H. Delaney and Marc Stiegler. I remember vividly when Valentina was born. In a chance meeting on a street corner in Chicago, Joe and Marc discovered that they had both been wanting to write essentially the same story. Both had been reluctant to tackle it because it required expertise in two

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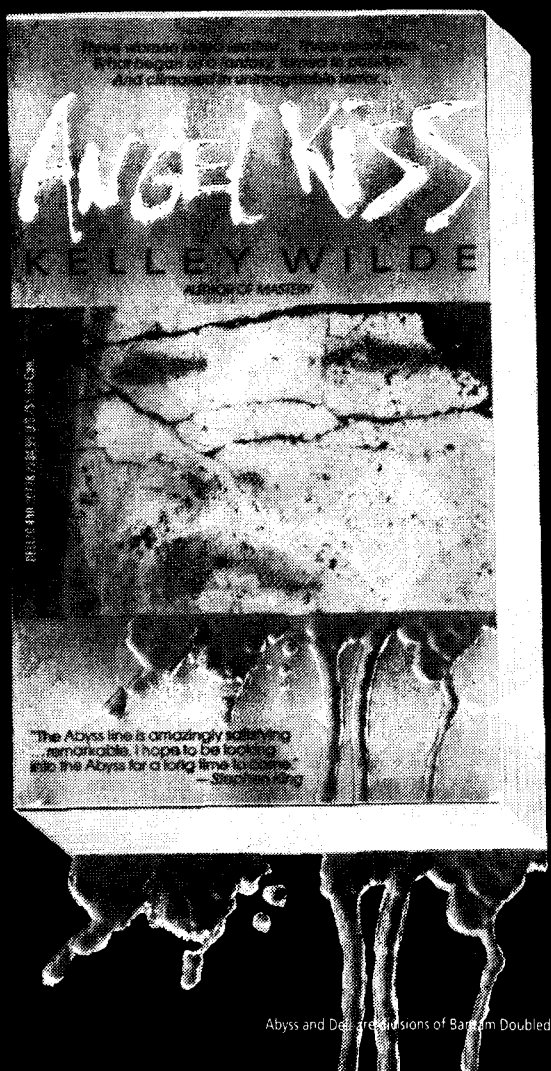
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fields, law and computer science. Joe was a lawyer, Marc a computer expert, and together they did a bang-up job on the story that neither felt qualified to do alone.

Yet in academia, experts in different disciplines tend to keep to themselves. In business and industry, isolation sometimes happens not merely by chance, but by policy and design. You've probably encountered managers who strove to keep departments under their supervision apart, confidentially telling Department A one thing and Department B another, and actively discouraging the two from talking to each other. Then there are managements which make decisions affecting the everyday working conditions of the rank and file without even trying the simple and obvious expedient of *talking* to the workers involved about what would make their lives easier or harder. I've heard, for example, of medical labs being remodeled by installing benches of an awkward height and fully equipped with piped gas—when nobody in the lab had used Bunsen burners for years, and probably never would again. Anybody who worked in the lab could easily have told the planners that the gas pipes were a pure waste of money that could have been spent on real and significant improvements—but nobody bothered to ask.

Keeping departments in the dark about what others are doing may be necessary in cases like the Manhattan Project, where secret research is being done on something of vital importance to national security and there is reason to believe that "spies are everywhere." I suspect the more usual case, though, is that every department of virtually any organization can only help itself by learning all it can from any other source.

In automobile manufacturing, for example, a marketing department can hardly benefit the company by promising features in next year's cars that the engineers, for technical reasons, can't deliver. On the other hand, if they ask, they may find that the engineers and toolmakers and assemblers *can* deliver something desirable that the marketers would not have thought possible. In book or magazine publishing, marketing people, art directors, and editors all expect covers to serve certain functions, and each group sees different priorities among those functions. If they talk to each other, regularly and openly, they have a good chance of getting covers that serve *all* those functions well. If they don't, they may get covers which one group thinks is terrific, yet which suffer a serious and potentially costly flaw that would be obvious to another group.

Most fields have become so large and complex that it's clearly not possible for everybody to have in-depth expertise in very many of them. Most of us can expect to spend a great deal of time learning the details of one or a few. But there's an important distinction between doing that and pretending that the rest of the world doesn't exist or is unimportant and not worth listening to.

I'd like to see a shift in the whole orientation of our culture, at the levels of both education and business,

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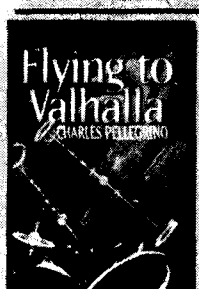

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in the direction of recognizing and accepting that everything is connected to everything else. In preparing for a career, I should learn very thoroughly not only how to do an in-depth study of a problem in my own field, but to recognize that yours may have something to contribute to it that I wouldn't think of on my own. To have some idea of what that might be, I should be taught and encouraged to keep up with at least the broad outlines of what's happening in your field—and as many others as possible. So should you. Neither of us should ever fall into the habit of thinking we don't need to do that any more. Whenever I suspect that my work might benefit from asking you about yours, I should feel free to come knocking on your door—and I should welcome you at mine when you think I might know something you need.

If a lot more of us developed such attitudes and practices, all forms of progress would benefit more often than not. The boxes in which we imagine fields of knowledge and expertise to be confined are artificial, not natural. They need fewer walls and more doors. ■

Thoughts, like fleas, jump from man to man. But they don't bite everybody.

Stanislaw Lec

It is with narrow-souled people as with narrow-necked bottles: the less they have in them, the more noise they make in pouring out.

Alexander Pope

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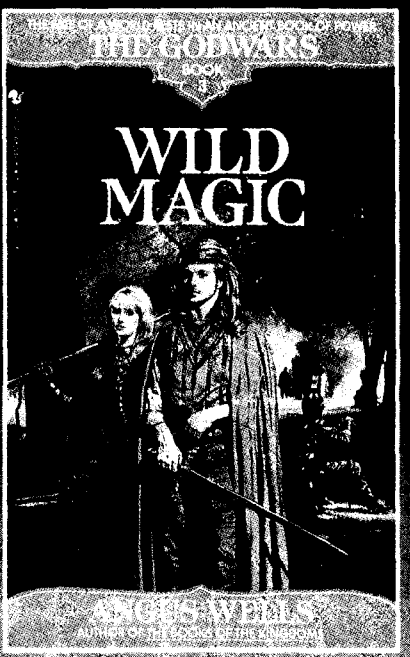

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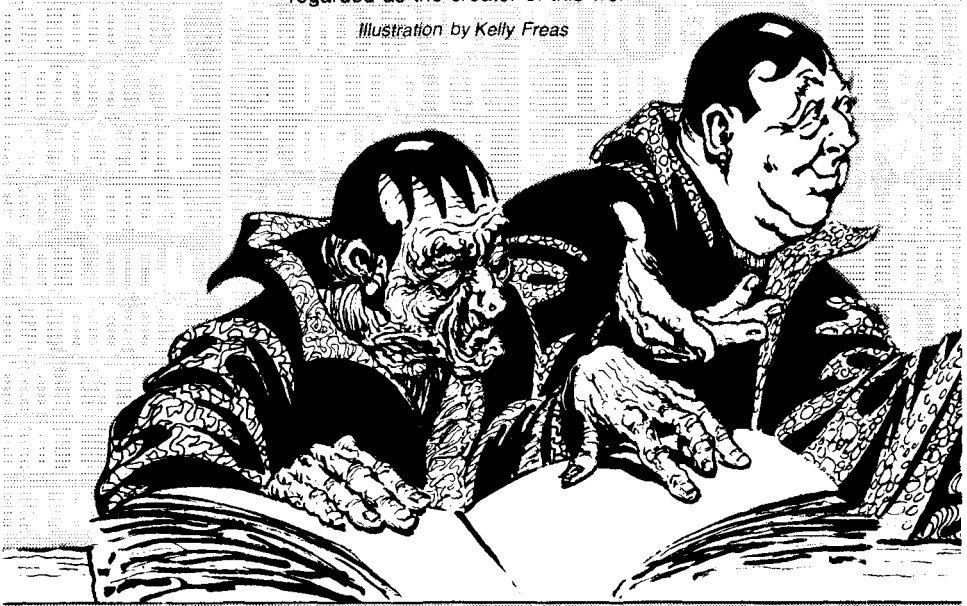

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When in Rome, at least learn to take advantage of what the Romans do!

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Looking distinctly unhappy, for what was happening fell far outside his previous experience, the portly country policeman made himself more comfortable on his stool, poised a stylus above what must doubtless be an incident report form, and said something incomprehensible.

"He wants to know your name, your age, and your profession," Hannah Lodge whispered. She had the advantage of the interpreter-computer that she wore as one of a rather smart pair of black and gold earclips.

"Jerry Faulkner," that worthy sighed "Fifty. Space-pilot."

She translated.

This planet was called Vorgrim. Emphasis on the grim. According to Hannah's gadget it had been colonized during the decline of the Euterpan Empire, since when it had forgotten almost all technology, the language had deformed at a rate of knots, and society had splintered into countless petty kingdoms and hierocracies. So far they hadn't found out which they'd stumbled on.

The policeman said the same as before and Hannah gave, presumably, the corresponding data for herself. Jerry listened, trying to catch the local equivalents of "interstellar trader" and "uh—thirty-nine," but the sounds were too unfamiliar.

Another question. Jerry looked inquiringly. Hannah shrugged.

"What do I trade in?"

"Hmmm. Tough one!" Jerry surveyed the crude stone walls and ill-hewn timber benches of the police station whither they had been escorted by a bunch of nervous farmers. If the latter had possessed guns they would have been inarguably trigger-happy; luckily their weapons were restricted to half a dozen agricultural implements. Slithes, was that the term? He went on, "I don't imagine they even have magnifying glasses, let alone the sort of microscope you need to see a nanotool. What are you going to tell him?"

"I'll just have to say ultraminiaturized medical and manufacturing equipment."

She tried it. The effect was impressive. The policeman's jaw dropped so far it nearly hit his desk.

And from there on down it was uphill all the way.

When eventually they were locked in a chilly cell for the night, with two meter-wide shelves by way of beds and a bowl apiece of over-salted soup for sustenance, Jerry demanded whether Hannah's interpreter had enabled her to find out what was to become of them.

"In the morning we are to be taken before—I quote this word for word—the honorable custodians of the perfection of knowledge."

"And who are they when they're at home?"

"Who knows? Some kind of high priests, maybe." She emptied her bowl, set it aside, and picked up the blanket that presumably was to serve as her coverlet. Pulling a face, she poked a finger through one of its many holes.

"Well-ventilated, at least," she remarked tartly.

Jerry looked her over, not for the first time, admiring her fire-red hair,

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her emerald eyes, and her freckles-and-cream complexion, and wishing, also not for the first time, they could have met in a context different from that of customer and charter pilot. However, wishing wasn't going to get them off this ball of mud. He said gruffly, "I never met a high priest before. What do you suppose they want with us?"

"To find out whether we're rational beings."

Jerry's jaw dropped nearly as far as the policeman's. "Isn't arriving in a starship evidence enough? Not," he added in a fit of honesty, "that *Fizgig* is a very impressive sort of starship. But she must have looked pretty spectacular on the way down."

Hannah waited ostentatiously until he had finished, then said, "Our policeman chum isn't very articulate, but he did manage to convey that we are to be—well—examined."

Jerry scratched his stubbled chin, wondering whether there were razors on Vorgrim. The locals they had met so far had all worn beards. "To establish how we measure up to the—how did you put it?—the honorable custodians of the perfection of knowledge; I see. And what is this knowledge that they honorably custode the perfection of?"

"Geometry."

Incredulous, he stared at her. After a pause he ventured, "Are you sure your earclip wasn't damaged on the way down?"

"That's what it tells me."

"Well, if they're going to examine us in that, we ought to pass without much trouble. Uh—the square of the hippopotamus is equal and opposite to the squares on the other two sines. Through a given point you may draw any number of parallel lines until you wear a hole in the paper. Cyclic quadrilaterals need four people to pedal them—"

"Oh, shut up," Hannah said wearily, lying down and spreading her blanket as best she could. "Remember we are on a backward planet and we need help from the locals if we're going to get off it again. You'd better start by being polite, at least."

"I guess you're right. OK. Good night."

"Good night."

Before dawn another policeman showed up. He greeted his local counterpart in a curious manner, by raising his left index finger. The greetee's response was to raise the right one. Having signed for Hannah and Jerry as though they were a consignment of fertilizer, the newcomer joined them in a jolting cart drawn by four dirty and barefoot young men. In response to Jerry's expression of disbelief Hannah uttered a single word to the policeman. The first time he shook his head; on the second try she elicited a whole sentence in reply.

"They're slaves," she reported. "I thought they must be."

"Slaves!" Jerry exclaimed indignantly. "How dare they!"

"They're held not to possess souls."

"Why not?"

"They don't understand the principles of geometry."

"You mean, if we fail this exam or

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interrogation or whatever—"

At that point, in a tone that needed no interpreting, the policeman ordered them to shut up, and the rest of the journey passed in downcast silence.

Within an hour or so they reached a sizable town, walled around after the fashion of medieval Europe. They were admitted through heavy timber gates guarded by yawning pikemen, obviously the night shift, who likewise went through the finger-waggling routine.

Beyond lay a maze of narrow streets, pungent with smoke as the inhabitants lit fires against the new day. As yet few folk were out and about; those who were, grimy-faced, clad in drab capes and cloaks, glanced incuriously at the strangers and went their way.

All the buildings were low-roofed save a tall square tower at the center of town—their destination as it turned out—and that was of a curious form. Its top was sliced off at 45 degrees. The higher side ended flush with its wall, while on the lower side it overhung. The shape looked as though it ought to be familiar, but it defied Jerry's best attempts to place it.

The policeman said something. Hannah translated.

"He says we must feel honored. The custodians don't usually get up this early, but they're all waiting for us."

"Bad news," Jerry sighed.

"What do you mean?"

"Do you like people who rout you out of bed before you're ready?"

"I take your point."

There were nine custodians, but only three seemed to count for anything, the rest being attendants. On the left was a scrawny old man in a yellow robe, his face fixed in a permanent glower. To the right sat a portly middle-aged man in blue, his expression benign but slightly confused, like someone just realizing that he is at the wrong party and should actually be next door.

And standing center front, in brown, was a tall thin youngish man who throughout the subsequent proceedings kept glancing at the one in yellow for approval. It wasn't hard to deduce that he believed himself to be in line for Yellow's job, whatever it might be.

Right from the start Brown did most of the talking, much punctuated with the finger routine. Hannah, of necessity, had to undertake the answering. Jerry chewed his lower lip and did his best to look appreciative of the favor that was being done them before breakfast.

Eventually Hannah turned to him. "So far so good," she muttered. "They're not about to decree that we're only fit for slaves. Yet. Now they want to know why we're here. You'll have to handle this."

"Don't they want to discuss geometry?"

"They haven't mentioned it."

"That's odd, isn't it. . . ? Oh well, I'll give it a whirl."

It went painfully slow. The Vorgrim language not being in its memory, the interpreter was having to ex-

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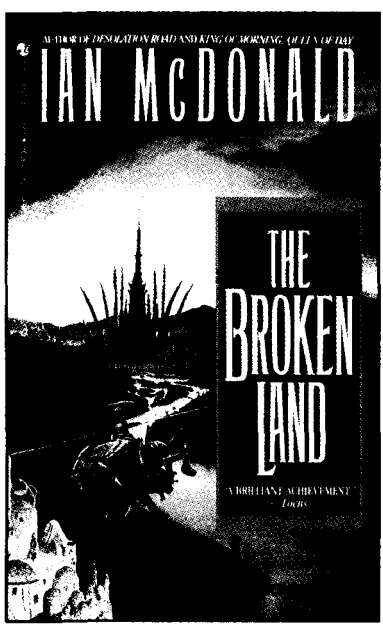

SPECTRA BANTAM

"It's true: All that is necessary for evil to triumph is that good men do nothing. Ethnic conflict will be the killer disease of the 21st century unless the Silent Majority ends its complacent silence. Having lived under the shadow of my country's Troubles for 24 years, I felt I could keep silent no longer. *The Broken Land* is the story of how Mathembe Fileli, herself silent, finds a new voice in which to speak and unite rather than divide.

Reaction has been curious: The closer I get to home, the more each side accuses me of being biased toward the other. I suppose I must be doing something right."

Ian McDonald

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trapolate it using laws of linguistic evolution that in this particular case appeared to have a great many exceptions. Moreover the locals had indeed forgotten technology. He even had difficulty with the concept of computers.

However, he managed to get across the key fact that they had had no intention of trespassing. *Fizgig* had been caught in a neutrino flux ejected by a supernova. It had corrupted essential navigational data and triggered an emergency landing procedure. Throughout the galaxy there were beacons against just such a problem, from which one could download replacement data, making a few thousand spare copies in case of corruption. This they would very much like to do, then get on their way before they missed the Solstitial Fair on Wytabit, where Hannah was hoping to dispose of several billion of her nanotools ahead of the competition.

"We'd appreciate your help," he concluded optimistically.

"In doing what?"

The question came from the man in blue. Hannah scowled. "He's right," she said. "You left that bit out."

Jerry would have liked to argue, but he couldn't. Cursing all women who were always right, he said as mildly as he could, "The nearest beacon is at Chlorosis Kappa. Unfortunately at this season it's below the horizon from where my ship came down—not by much, but enough. We need to carry a receiver some two hundred kilometers south."

"You can't fly that far in your wonderful machine?" Brown said sarcastically.

Jerry repressed sundry base impulses. "Regrettably, once the emergency landing procedure has been activated it's not permissible to take off again with incomplete navigational data."

Yellow leaned forward and spoke in a thin harsh voice. Hannah translated, looking worried.

"Do we realize what we're asking for? They'd have to send an armed expedition into hostile territory!"

Brown rapped an order. One of several guards, who seemed to have nothing better to do than stand around looking impassive, brought him a hand-drawn map. With its aid he made it clear to the strangers that the country they were in, Yubble, ended just beyond where *Fizgig* was lying, and the neighboring country, Gleege, disapproved of visitors, especially from Yubble. There seemed to have been a war that ended inconclusively, which both sides hoped to restart as soon as they felt confident of winning.

That sounded as though it was that. The alternative was obvious: they'd have to find some means of earning a living until Vorgrim's libration brought Chlorosis Kappa back into line-of-sight from Yubble. Which would take months. And on a planet this decadent there couldn't be many job openings for a merchant selling nanotools, let alone a space-pilot. Gloom descended, almost tangibly.

And was, if not dispersed, partly dispelled from the least expected quarter. Sourpuss Yellow said some-

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thing, and Brown enthusiastically echoed it. All the custodians nodded more or less vigorously. Hannah translated.

"He says this is too precious an opportunity to be missed. They will mount such an expedition—on one condition."

Jerry's heart leapt optimistically. "That being—?"

"We must agree to take missionaries with us when we leave, so that the perfection of knowledge can be shared with other worlds."

Jerry's heart unleapt. "No way. Two is *Fizgig's* maximum load."

That provoked incredulous exclamations. Jerry could see why. His little ship must seem immense to people who knew no sort of transport more advanced than carts hauled by slaves. However, the fact stood, and because of it the offer of the expedition was withdrawn.

"So what do we do now?" he asked Hannah caustically. "Find out which local papers carry help wanted ads?"

But his sally fell flat. For Brown was making a suggestion that endeared him simultaneously to both Yellow and Blue.

"If they won't offer passage to our missionaries, they must serve as missionaries themselves! Let us, from the goodness of our hearts, educate them in the sole unique unparalleled right way. They say the star they need to see will be visible in half a year. They can occupy the time fruitfully. And if they are indeed rational creatures, which I personally question, they cannot fail to be persuaded of the transcendent truth of our geometry."

Yellow nodded thoughtfully. "An excellent proposal. Do you not agree?"—to Blue.

"Oh, yes! Marvellous, wonderful, what insight; I shall do my utmost to live up to such responsibility!" burbled Blue.

Brown, Jerry noticed, wore a mocking smile.

"Why do we not make a start now?" he proposed. "The day's classes are almost due to begin. Let them join the very lowest, along with the youngest children, for they were born to ignorance in outer darkness and saving them will be a long and weary task."

Implicit in that sentence were scores of echoes of his future "Told you so!"

Looking less than enthusiastic Blue said, "Very well. Let guards lead them to Teacher Thull's class, right away."

"I have been in embarrassing positions before," Jerry said between clenched teeth. "But this takes the Grand Algolian biscuit, with plums and icing."

With the utmost difficulty, and to the accompaniment of giggles from a dozen or so eight-year-old children, probably of both sexes but wearing identical much-concealing clothes, he and Hannah had crammed themselves into desks matching theirs. The school itself was a patch of ground under a tree. The desks faced a blank wall. There was no sign of anyone who might be Thull.

"What bugs me," he went on aggrievedly, "is that they haven't set up an examination to see what we already know. Your computer—"

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There was a shuffling noise. The children rose to their feet, chorusing something that could only mean, "Good morning, teacher!" Belatedly Hannah and Jerry had to unfold and then refold themselves as Thull arrived. He proved to be a brown-haired, pleasant-looking young man in grey. Accompanying him was an olive-skinned, black-haired girl of eighteen or twenty, attractive in a flat-faced way, wearing dark red jacket and trousers: a completely different garb from any Hannah and Jerry had seen since landing. They assumed her to be another teacher, for she was patently on familiar, not to say intimate, terms with Thull, but to their surprise she too proceeded to cramp herself into one of the undersized desks.

And stared at them with frank curiosity while Thull learned from the guards who they were and what he was supposed to do with them.

His expression harassed, he ran his fingers through his hair and addressed a question to his new "pupils." Hannah answered. He looked a little but not much relieved.

"He said—" Hannah began. Jerry cut her short.

"He wanted to know how he's supposed to teach us if we can't understand what he's saying, so you set his mind at rest. Correct?"

"Very good!" she exclaimed with mock admiration. "And?"

"Was there something else?"

"There was indeed. Going back to square one will mean the rest of the class falls behind the prescribed schedule, but since this is an order from the custodians he'll have to comply and hope it'll pass as revision. Didn't get that, did you?"

Jerry didn't answer. He was staring at what Thull was producing from a chest parked against the wall. This school, apparently, didn't boast any teaching aids as modern as, say, a chalkboard. What he was arraying in sequence was a series of engraved panels with symbols on it. These, it swiftly became apparent, were to be copied—flawlessly—and committed to memory.

Exchanging puzzled glances, they tried to make sense of the first one. It bore groups of lines, some intersecting, some merely placed together, along with an assortment of dots, dashes, and curlicues. Against each appeared something more familiar: deformed but recognizable numerals.

Propping that up where it could be seen, Thull set next to it another which showed a selection of the symbols ranged in four lines. Jerry felt an itch of insight.

"He doesn't expect us to learn as quickly as Fee," Hannah reported under her breath—Fee manifestly being the girl in red. "Fee will now show us how much she has learned in the short time she's been here."

Clearly relishing this flattery, Fee duly read or perhaps recited a short sentence.

"The way to truth is via constant study," Hannah rendered with the help of her earclip. "So it is writing! But they were so insistent that we were going to study geometry.... Oh! Of course! Not geometry, though it was the same word originally. *Gem-*

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atria!"

She was half out of her seat with excitement, which was quite a feat considering how snugly it fitted round her hips

"What in all of space is that?" Jerry demanded.

"A mystical system that allots number-values to letters, so that as well as its ordinary meaning each word has a concealed value supposed to link it with other words whose letters sum to the same."

"You mean—uh—you wind up with two words that both total ninety-nine, so—"

"Not quite. You add the nines to make eighteen, then you add the one to the eight and get nine again—that's an especially magical number—and that's supposed to imply some fundamental connection between all the nine-words. People used to spend their whole lives searching for such connections. Treatises were written on the subject. It's not going too far to say that wars were fought over rival interpretations of holy texts."

Jerry was staring. "I knew people were crazy in the old days," he said disbelievingly. "I didn't realize they were *that* crazy! Do they think it operates in base eight, too?"

"Be careful," Hannah warned. "These people must take it very seriously indeed. Uh, I'm sorry about that," she added to Thull, forgetting it was in the wrong language. Some of the children sniggered, then looked angelic at the teacher's frown.

Aided by her computer, Hannah rephrased her apology in Vorgrimish, then went on, presumably, to repeat what she had just told Jerry. Thull's face lightened with every word, until at the end he was beaming.

"He had imagined we knew nothing about the subject," she relayed. "He's delighted to find he's wrong. We know so much already we're sure to outdo even Fee."

This did not please the latter at all. Her scowl could have frozen hydrogen at twenty parsecs.

"Can you tell me a bit more?" Jerry requested. "I may need it."

"Just a moment. I'll have to do some heavy programming. See, on this panel he brought out first the letters are grouped by values, not sounds. And I bet there are exceptions. Their language has drifted so far from the galactic norm in such a relatively short time there are sure to be obsolete pronunciations and inflections that have made the transcriptions non-phonetic."

"Are you learning all this from your computer or is it something you know about already?"

"Language change I know about, of course. I've done business in fifteen systems. But I never expected to meet people who'd reverted so far towards the primitive that they believed in this kind of—"

"Most interesting!" Jerry exclaimed loudly, wishing he could twist around in the constrictor clutch of his desk and kick her on the shin. "I'm certain if we buckle down to it we'll get the idea in no time, especially with Teacher Thull to help us! *Translate!"*

Hannah's eyes widened as she realized how close she had come to say-

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ing something they might both have regretted. If anyone on Vorgrim could still understand Galaxpeak, wasn't it likely to be a teacher? Hastily she covered her *faux pas* by requesting Thull to expatiate on the sounds and number values of all the glyphs. Those data loaded, she asked to be shown the rest of the panels in turn. She read them aloud, albeit stiltedly; she calculated the numerical totals of each word, each phrase, each sentence and the complete quotation that each panel bore—a precept or an apophthegm. She made tentative suggestions concerning connections between one panel and another, observing for example that three of them successively totaled four, five, and six and another trio six, seven, and eight. Modestly she forbore to guess what, if anything, that might signify. Thull, by now, was practically purring.

Noon arrived. The children, dismissed, sat down under a tree a short distance off to eat packed lunches. Jerry eyed them wistfully.

"Think there's a decent restaurant around here?" he muttered. "I'll wash dishes if I have to."

Hannah, however, was trying to wheedle information out of the no longer offended Fee, and meeting with remarkable success.

Partway through the morning, though, Thull had dispatched one of the guards with a message, presumably concerning Hannah's extraordinary insight. It was now that the man returned. Beaming more than ever, Thull repeated what he had to say to Hannah.

"We can do better than washing dishes," she informed Jerry. "We're invited to chow with the blue-robe custodian. His name's Wulgo. He's responsible for archives and education. Thull and Fee are coming too."

"So who is Fee?"

"She's a princess."

"You're joking!"

"No, literally. She's the daughter of King Nolon of Gleege."

"What's a princess doing at school on her own? Shouldn't she have a whole gaggle of slaves?"

"Ah. That's interesting. In Gleege they don't approve of slavery. Brown Robe didn't tell us what started that war we heard about. Slaves from Yubble keep fleeing across the border. Can you blame them? So every now and then Yubble invades to try and drag them back. Most of the time they succeed because the Gleegers, being only human, don't care too much about laying their own lives on the line for the sake of foreigners."

Jerry sighed. "That figures. The sort of mess that can only be fixed when Yubble gives up enslaving people. So?"

"So part of the deal that ended, or rather suspended, the latest set-to was for Fee to spend five years here as a hostage, so naturally she's being forced to study geometry, same as we are. She doesn't like it much, but Thull does."

"I'd noticed," Jerry murmured. "Anything else?"

"After lunch we will be granted a guided tour of the holy of holies."

"That being—?"

"I'm not sure. All I am sure of is

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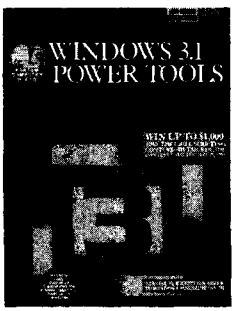

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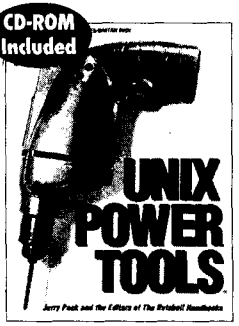

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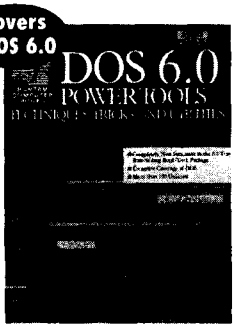

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that lunch is likely to be one long lecture."

Hannah was right on that score. Wulgo ate scarcely a mouthful of the indifferent meal, expatiating on the Yubblers's unparalleled grasp of the fundamental nature of the universe, which could all be boiled down to the nine digits. Before his guests' plates were empty or their bellies full, he hoisted his not inconsiderable bulk out of his chair and waddled ahead of them to a gaudily decorated stone building outside which waited a line of sad-faced folk of both sexes and all ages, being admitted by dribs and drabs to the interior. Wulgo had his guards force a way to the front of the queue.

There, behind an iron grille, reposed a huge handwritten book. It was open about two-thirds of the way through. Hannah leaned over to inspect the text, read it aloud more or less accurately, and appended a translation for Jerry: " 'Obedience to one's natural superiors is a universal law. Those who cannot recognize their superiors must be enslaved until they do.' The value of this folio," she added, "is six."

"Why, it's true!" Wulgo said warmly. "You have an instinctive grasp of geometry! If your companion can match you, we shall have to mount that expedition after all!"

"Jerry?" Hannah prompted.

"Ah . . . " He cleared his throat. His mind had been on Fee. Whether she knew the purpose of the said expedition he could not tell, but he suspected she could guess its destination. Her face, however, had become a mask. "Certainly I understand the principle. But how can you be so sure that your system of assigning numbers to the letters and the—the whatevers is right, and the rest are wrong?"

"An acute question," Wulgo said solemnly. "But the answer's simple. Our forebears proved by trial and error that it must be right, for it's the only system according to which the sum of our Book—and it's no small volume, including as it does a folio for every day of the year, so that each day you visit it you read a different moral message, the totality of which comprehends all wisdom. We permit even slaves to enter and learn, as you must have noticed, although of course they can only come on a free day and if they offend their masters years may well elapse before they manage to peruse every folio, and until they do so . . . where was I? Oh, yes. Our ancestors finally discovered *the* system, according to which the generated number of the Book is the number that signifies irreducible perfection."

All present save the foreigners raised their forefingers.

"Of course!" Jerry exploded. "Your tower! It's a figure one!"

"It memoralizes the greatest achievement of our savants," Wulgo said proudly. "It cost centuries of disappointment and false starts. Come this way."

He led them to an adjacent and much larger chamber. Scrolls and books filled shelves more than head high and thirty, forty, fifty paces long.

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Each section was identified by a numbered wooden tag swinging from a string. But the place was empty apart from a blear-eyed copyist who raised his head for a moment, then went on totting up the letters on the page he had last transcribed to make sure there were no errors.

"What's all this about?" Hannah inquired.

"There must of course be one and only one copy of the complete Book," Wulgo said patiently. "To infringe its uniqueness would be blasphemy. But our scholars could not limit themselves to reliance on the single master copy. Besides, copies of copies are required for teaching—the sort of thing that fellow over there is at work on. Accordingly sections of the whole were copied and kept separate, while match after trial match was put to the test. How often success seemed within reach as our ancestors pursued their heroic labors, only to fail at the last sentence, the last line, the last word, the last stress-mark. . . . And what rejoicing there was when they totted up the sums of the folios according to the true equivalence, and found the result was exactly a thousand!"

"Meaning," Jerry said with a frown, "they could reduce it to one."

"You grasp the principle perfectly!"

"But what made you—I mean your ancestors—so determined to find a way of making it all add up to one?"

Wulgo looked shocked. Thull stabbed his forefinger into the air.

"Because it's the number of perfection! I just told you!"

"But—"

Hannah trod hard on his toe, murmuring with the sweetest of smiles, "So sorry!" And, maintaining the smile, went on: "We understand very well. Why, one is the only actual *number* used by the computers in our spaceship. You can't really call zero a number, can you?"

"Of course not!" Thull and Wulgo concurred.

"I find the whole thing fascinating. Tell me: you say you turn the pages of the Book day by day, so to read the original I'd have to stay here a full year. Well"—archly—"I do hope to take you up on providing that armed expedition if we pass your tests. You did say that was what we can look forward to, didn't you?"

"Oh, yes!" Fee exclaimed, and Thull echoed her, much to the discomfort of Wulgo, who shifted awkwardly from foot to foot.

"Well—uh—"

"That's what it sounded like to me," Thull declared stoutly. "And we are pledged to the absolute truth, aren't we?"

"I'm sure, I'm sure!" Hannah exclaimed. "However, I can read the entire text of the Book, can't I? I mean I can read these copies that your ancestors made." She waved at the dusty books and scrolls.

"Yes, of course," Wulgo agreed. He looked and sounded worried, as though he feared a trap was being set but couldn't guess where.

"I'd like to start right away, then, please."

"Well, you're certainly eager enough . . . I don't see how I dare re-

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fuse so keen a student." With sudden sharpness: "You understand I'll have to post armed guards over you? And hold your friend as security for your good behavior?"

"I'll stay here," Jerry said hastily. "I'd like to read the whole of the Book, too."

"No." Wulgo spoke with finality. "You go back to Thull's class. I'll be interested to hear how much progress you make on your own. I think so far you've been hiding behind your friend's words. You've got to do better than that to qualify as a missionary. Thull, bring them both to me at end of school."

Vague and ineffectual Wulgo might appear, Jerry realized, but he was hardly likely to have attained custodian rank without a streak of ruthlessness, not in a culture that kept slaves and fought wars. Following Fee as they returned perforce to the class, he found himself wondering what went on in the mind of a barbarian princess, and came to the conclusion he probably preferred that of an interstellar trader.

He and Hannah were duly reunited once the children had dispersed to their homes. When she was released from the scroll-room, she wore a puzzled, and puzzling, expression. Inscrutable would be the term. She responded absently to Jerry's inquiries. To Thull, who wanted to know what progress she had made, she said, "Oh, I've read the lot."

"And—?" he breathed in wonder.

"And I think I'd better talk to Wulgo first."

Word somehow preceded them. When they entered Wulgo's presence again he was looking even more worried than earlier. After the usual finger-wags, which Jerry optimistically imitated only to find he had used the wrong hand, he said, "I understand you claim to have read the full text of the Book."

"Yes. A copy of each of its sections, that is."

"And?"

"They don't add up."

"What?"

"The copies don't add up to one. They add up to two."

"Nonsense!" Wulgo roared, as Thull clenched his fists and the guards waved their forefingers and Fee looked first astonished, then delighted. "They were checked and rechecked and then checked again!"

"I assure you it's so." Hannah drew a deep breath, adjusting her earclip computer. Irrelevantly Jerry wondered why she wore its pair, for she had never referred to it. Just for the match, he supposed.

She went on, "I assume that as a custodian you must know the Book by heart. If it were destroyed you could reconstruct it?"

"Yes, of course. Any of us could."

"Very well. I'll start at page one. You keep count. See if you can spot where they went wrong. 'The universe began—' "

"Stop! So grave a charge must be heard by all of us! Guards, summon my fellow-custodians!"

There ensued a period of controlled panic. Not only the rest of the custodians but strangers by the score

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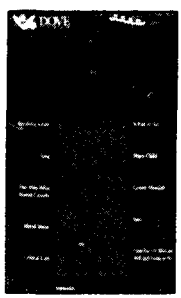

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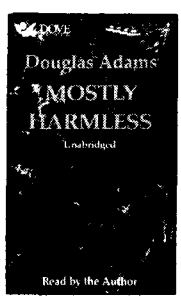

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came running. Jerry whispered to Hannah. She ignored him. He stared questions at her. Her face remained stony. He thought of shouting at her, though in the upshot he didn't, for it was all too clear what might happen if the foundation of these people's cherished beliefs were to be overthrown. Or maybe all too unclear. Either way they weren't going to be polite to strangers who had shown them up as dupes.

Brown arrived first, with his acolytes, denying at the top of his voice that there could be anything wrong with the ancestors' counting. Yellow followed, wheezing and swaying, and had to be installed in a chair by his attendants. There he sat mumbling to himself until Wulgo ordered silence, to Brown's annoyance, and invited Hannah to begin. Three attendants poised styli and writing blocks. Drawing breath afresh:

" 'The universe began. . . ' "

It took hours. After every folio the scribes compared notes; every time they were in precise agreement. Then, abruptly, silence fell.

"I don't remember that as right," Yellow wheezed.

"Nor do I," muttered Blue.

Brown declared, "She must have tampered with the copy!"

"What page have you got to?" Jerry inquired of Hannah.

"Page 340. Towards the end. Small wonder if the copyists grew tired enough to make mistakes after such a long—"

"Hold your tongue!" Brown shrieked.

Composedly, Hannah did as she was told. After much further argument the entire meeting, with her and Jerry being chivvied along at spearpoint, was forcibly adjourned to the scroll-room. All copies of page 340—there were several—were examined. Expressions like the knell of doom became as common as dust-motes in a comet's tail as they slowly realized: the total of letters and diacritics on every copy of this page did add up to one more than it should have done. In which case the entire Book—

"She must have changed it!" Brown blurted. "Wulgo, you fool! Why did you allow her in here by herself?"

"I didn't!" Wulgo flared. "Guards were with her at all times! You were keeping watch, weren't you?" he added to the pikesmen.

"We obeyed your orders exactly," one of them said stiffly.

"Besides," said another, "what could she have used to alter it? She has no pen or stylus or anything to make a mark with."

"We searched her to make sure," the first one said, earning a glare from Hannah.

"Did you order that?" Brown demanded of Wulgo.

"Ah—not exactly! But I believe in encouraging initiative even among slaves!" He wiped forehead sweat with his sleeve.

"Shall we continue?" Hannah suggested. The custodians had perforce to consent.

And in the end, long after sunset, they were driven to yield. If the copy of page 340 Hannah had consulted was accurate—and it matched all the

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others that she had not had a chance to handle—the precious Book did not sum to unity after all. The air filled with a buzz of sullen disagreement.

"I don't understand why you won't do the obvious thing," Jerry said at last, and asked Hannah to translate. Burning eyes turned on him.

"Pray, what do you think is so obvious?" rasped Brown.

"Well, Hannah wasn't allowed to touch the Book itself, was she?"

"I didn't dare go near it," Hannah confirmed. "I'm sure if I'd tried I'd have had a spear through my guts."

"Ah!" Yellow sighed with relief. "Of course. Even if there was a copying error that has somehow been repeated, the original—"

"But it's not the day to turn to page 340!" Wulgo cried. "There's three weeks to go!"

Hannah's face fell.

"Hear, hear!" Brown exclaimed, sweating worse than Wulgo.

"No!" thundered Yellow—insofar as he could thunder in his reedy old voice. "Don't you realize what could happen in three weeks, you idiots, with rumors of the Book's imperfection spreading like gump-ill? Slaves could become disaffected! Gleege might take advantage and invade us for a change! There's no end to the awful possibilities!"

Jerry might have been the only one to notice how Fee had cheered up, or again he might not. At all events she looked extremely perky.

"Do it now!" Yellow insisted. And when the others failed to react: "Am I or am I not still the chief custodian? In spite of *your*"—that was aimed, predictably, at Brown—"intrigues designed to impeach me as senile! I've read the Book more often than you've eaten hot dinners, and I *know*, you accursed doubters, you fainthearts, you backsliders, I *know* that page 340 adds up as it always has, to two! Just as page 341 sums to six and 339 sums to five! Bring the key to the grille!"

"Curious," Hannah said musingly, "that the page-numbers don't total the same as the words. I'd have expected that in a *true* system—"

"*Shut up!*" bellowed Brown, but she had put her point across. Jerry noticed a look of bewilderment on Thull's face, as though this was a point he felt he should have spotted himself. He reached out to link fingers with Fee, who was grinning. Also the guards were exchanging meaningful glances. He thought about the law of natural superiority and what might happen to it.

Its overthrow, though, was too much to hope for. It was clever of Hannah to have tampered with the sacred text, but if she hadn't been allowed near the original, once its page 340 was examined the matter would be settled. Sowing seeds of disbelief was a neat idea, but he doubted they would generate useful results any sooner than if they simply waited for CK to rise above the horizon next spring—

Abruptly he grew aware that a great stillness reigned.

"It's impossible," Yellow whispered.

"I don't believe it," Wulgo whimpered.

"It's a plot!" Brown shrieked. "A

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plot against me, by you!"

"Shut up, paranoid fool! There's nothing else for it but to count the original again, line by line and word by word—"

"Now you're saying our ancestors couldn't add up!"

"I bet that's not the only mistake you've introduced! Devils like you will stop at nothing!"

"The Book has to be perfect! It must sum to one!"

"Maybe we've made so many copies, it isn't unique any more!"

"I knew you were jealous, but I never dreamed you'd do *this!*"

"Guards! Stand by your chief custodian!"

"Guards! To me, librarian and archivist!"

"Guards! Ignore these renegades! They've stooped so low in their vendetta against me, they've sabotaged the Book!"

While the guards were trying to decide whom they should obey, Jerry felt a touch on his arm.

"Let's leave them to it," Thull whispered. "I live not far from here. I think we ought to talk."

"So do I," Hannah concurred. Jerry wavered for a moment.

"Also food by his landlady is better than Wulgo's," Fee asserted.

That settled it.

It turned out to be a noisy night. Whatever gump-ill might be, rumors were indeed spreading like it. From door to door along what should have been curfew-vacant streets, across roofs from one dormer window to the next, people were relaying "news," snippets of which in due course arrived at Thull's lodgings. Different stories had taken rise in different quarters of the town. One of the custodians was in Gleeger pay. A suppressed page of the Book had been rediscovered, corresponding to Leap Year Day (Vorgrim's calendar called for one every five years, said Hannah's computer), and it contradicted the whole of the rest. It wasn't that certain children were incapable of understanding geometry, it was that they were prevented from studying it so as to keep up the supply of slaves. The public had been taught to use the finger greeting wrong hand first; the custodians did it the opposite way in powerful secret rituals that maintained their supremacy....

How he managed to get any sleep, Jerry never afterwards understood. The tension in the air was almost suffocating. One half-expected an earthquake.

"Things are going to be different in the morning," murmured Thull.

At breakfast there was no sign of Fee. "Where is she?" Hannah inquired.

"With luck, over the frontier," Thull replied.

"Are you a Gleeger agent?" Jerry demanded.

Thull shook his head. "Just a slave."

Hannah started. "They employ slaves to teach geometry? But—"

"You thought people who understand geometry are entitled not to be slaves?" Thull's tone was bitter. "Everyone in Yubble, over the age of twelve, who hasn't read every page

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of the Book is in principle a slave. Parents, slave or free, drive their children to look at, if not understand, all the pages before their twelfth birthday. Woe betide them if they don't manage it. And the custodians put every obstacle they can in the way of any children save their own."

"You," Hannah said shrewdly, "beat the deadline."

Thull nodded, his face suddenly gaunt and downcast. "Bar one page. They found excuse after excuse to keep it from me—and seeing a copy doesn't count! I can recount the full text of the Book as flawlessly as Wulgo, and that *still* doesn't count!"

"So—" Jerry began foggily. Thull cut him short.

"Now I'm permanently disqualified. I'm a slave. Period."

"An odd kind of slave who's friends with a princess!"

Hannah snapped her fingers. "I think I— Thull! Did you run away to Gleege but get recaptured?"

"Mm-hm."

"Did you meet Fee while you were over there?"

"Mm-hm."

"Were you—?"

There came a smashing sound. Half a brick wrapped in paper flew through the window of the room where they sat, narrowly missing Thull. He snatched it up with an oath. The paper bore a message. He read it aloud.

"It's from my most diligent pupil—apart from you, Hannah, and Fee! 'We won't be in class today or ever again!' " His face altered magically. "Wow! It's running out of control far faster than I ever dreamed could happen! I can stop pretending at last! Let's go see what's going on!"

It was a different city from the one they had entered a scant day ago. Almost every wall had been daubed with slogans relating to the Book, prominent among which was the simple number 340. People were arguing, shouting, sometimes fighting in the streets, the day's normal business forgotten. Children skiving off from school were dodging truant officers who, themselves being slaves as Thull explained, made only a nominal attempt to take them in. In front of the custodians' homes crowds were assembling, bearing hastily-contrived signs such as LET US READ THE LEAP YEAR PAGE and ONE OR TWO? MAKE UP YOUR MINDS!

"I bet," Hannah said softly, "the custodians are capable of inventing all sorts of logical reasons why the Book now sums to two. Most likely they'll call it growth. A few may even risk predicting that in a century or so there'll be a further advance, to three."

Thull curled his lip.

"Your saying that confirms a point Fee and I often discussed while I was in Gleege. Over there they maintain you can invent associations between no matter what kind of nonsense and still come up with pseudo-logical justifications."

"So one oughtn't to take that sort of thing seriously?"

"Correct."

Their progress grew slower and slower. They were approaching Fig-

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ure One Tower, which was encircled by a suspicious and potentially bad-tempered crowd. Eventually they became immobilized, just as a tall girl with a shrill voice compelled a man standing next to her to bend over and create an instant speaker's platform. From it she shrieked, "Haven't they finished their recount *yet?*"

"I don't think they can!" called a man twenty meters distant. "Did you ever know a dawn when they wouldn't let people enter and read the precept for today?"

A collective indrawn breath from the throng. Someone shouted, "Can't be so!"

A gruffer voice rang out. "It's true! I was assigned to tally-keep this morning. There's a little girl who needs just one more page, and it's today's, and they ordered me to slam the gate in her face!"

A moan of horror swept the assembly, like wind brushing a field.

"The recount is sure to be a lie!" a shrill voice declared. "They told us a lie before and never let us check it! That means it *was* a lie!"

Shaky though the logic might be, that was the signal the crowd had been waiting for. The guards protecting the custodians' mansion homes were slaves as well. None of their interests was at stake, and if they broke training now they stood a pretty fair chance of a better future. For once (and it was a rare treat, Jerry recalled afterwards) it was possible to witness human beings behaving in a rational manner to maximize their joint collective benefits, rather than being swayed by a demagogue or cowed by a tyrant.

So the guards, intelligently, lent their arms and shoulders to the forefront of the crowd, to force down the gates of the custodians' homes. Having collected and hobbled all nine, they dragged them to the place where the Book was kept.

Thull, fists clenched, was bouncing up and down. "Pray that they don't still have a trick up their sleeves!" he moaned. "If the people who've been counting all night have come up with a different way to make the total one, so the stinking priests can go on claiming they were right in the first place—"

"If they try it," Hannah cut in, "take a lead from Jerry and tell them to prove it also holds in base eight."

"Base what?"

"Don't worry. It shouldn't be necessary— Look! I was righter than I knew!"

The crowd around the entrance to the chamber where the Book was kept was parting before a haggard group of elderly men, ink-smeared to their elbows, their eyes wide and red-rimmed, their voices husky and their words unclear.

"Are those the people who have spent all night counting the Book?" Jerry demanded.

"I suppose they must be," Thull replied.

"What are they saying?"

"That the text adds up to three, or two, or eight, or five, or—"

One of the persons in question shrieked at the top of his voice.

"He says it's magic. There's a curse on them. He personally counted one

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of the sections twice, and the first time it made eight and the second nine, yet there wasn't any difference in what it said!"

Light belatedly began to dawn on Jerry. He leaned close to Hannah.

"Tell me: what do you use your other earclip for?"

"Well, I have to keep my samples somewhere."

"Working samples?"

"What else?"

"You mean the Book will never again add up the same way twice."

"Do you think that's any loss?"

"Not at all."

"Good. Now all we have to do is wait for the Gleeger invasion, which will be the first in fifty years and will encounter zero resistance partly because all slaves will take the Gleeger side immediately and partly because—"

She gestured. The mob was hauling Wulgo out of his house, heedless of his screams, and chasing him down the street with mud and insults.

Thull had been clapping wildly along with the rest. Suddenly it was as though he had recorded rather than heard the last exchanges between Jerry and Hannah, and only now registered their import. He rounded on them, blinking repeatedly.

"Hannah, it was you who did this?"

"Did what?" she parried suavely.

"I don't know! But the people trying to count the Book—!" He made a helpless gesture.

"Yes, they won't have much luck."

"How? *How?*"

"If I tell you, will you guide us to the nearest place we can link up with King Nolon's army? We need to take a receiver—"

"To where this beacon star's in line of sight! I know! OK!"

"All right." Hannah smiled. "I deal in nanotools. They're so tiny, I could throw a thousand in your eye and you wouldn't even brush them away. I keep my stock here." She touched one earclip. "Editing your Book under the direction of the computer that I wear in this clip on the other side—they're interlinked, and with my brain—was literally no problem. Matter of fact, it's been kind of fun."

"Editing?" Thull repeated foggily, while Jerry stared at Hannah as though he had never met her before.

"Making changes. What did yesterday's folio say?"

"What was yesterday? . . . Uh—it was the one about obeying one's natural superiors!"

"And it added up to . . . ?"

"Six, of course!"

"During the night," Hannah said demurely, with downcast eyes, "it was found to add to four, nine, and seven."

"What?"

"Your ancestors grew so desperate at the last to make things come out as they wanted, they resorted to piling special cases on exceptions upon alternative forms. Are there not fifteen signs with the value one?"

"Ah—yes!"

"And are any of them actually pronounced?"

"No!" Thull clenched his fists.

"Why?"

"Because the sacred number is reserved until . . ."

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Canceling the urge to raise his forefinger in symbolism of the sacred number, he dropped his arms to his sides.

"I ought to have spotted this while I was in Gleege, oughtn't I?"

"Yes," Hannah replied with composure. "It being the only period of your life when you enjoyed any degree of freedom. However, people like you often don't know how to take advantage of freedom when you have a chance at it. D'you think Wulgo will?"

"Freedom?"

"Well, he's been deposed from his role as a custodian, so the only thing still shackling him is the Book, and as for the Book. . . ."

She dismissed it with a shrug. Wailing, Wulgo came stumbling back towards, then past them pursued by a gang of joyful children cheered on by their mothers.

"Don't I recognize some of those kids?" Jerry murmured.

"Yes."

"Then you're a pretty good teacher, aren't you, Thull?"

"It's not exactly our style to invade other people's territory," said King Nolon of Gleege, stroking his tawny beard. "On the other hand, anything we can do to spare our own land from trespassers. . . ." He grinned, glancing fondly at his daughter.

"Well, here's your receiver," he went on. "Carried as requested to the top of a suitable hill, aimed at Chlorosis Kappa, and exposed on the correct frequency. You put us to a lot of trouble, you know, though I guess it's a fair exchange." He hesitated. "What I most want to know is this. If you, Hannah, were wearing earclips containing on one side a comprehensive computer and on the other millions of nanotools, why wasn't Jerry wearing say a bracelet, holding all the navigation data he might need if the ship's memory was knocked out?"

Jerry shrugged.

"You have bureaucracy here. We saw the Yubble version in action—meaning inaction."

He was making fair progress in the local tongue—belatedly, since he sincerely hoped never to need it again—but that play on words fell flat. Fee said in a puzzled tone, "It happens everywhere, doesn't it?"

"Bureaucracy? Yes."

"So—?"

"Bureaucracy six thousand years deep?"

"Oh."

"Yes, you can get awfully fossilized in that time. . . . Look, King, we have to rush. The fair on Wytabit begins tomorrow, and Hannah needs to get her setup ready."

"We want to hold a state banquet for you! Can't you stay?"

"Let the thought stand for the deed. If it couldn't, what would become of most scientific hypotheses? Goodbye! And thanks!"

It wasn't until *Fizgig's* ascendant vapor trail was blurring among cirrus that Fee said in a puzzled tone, "Do you suppose they left in such a hurry because . . . ?"

There was no reply. How could there be? ■

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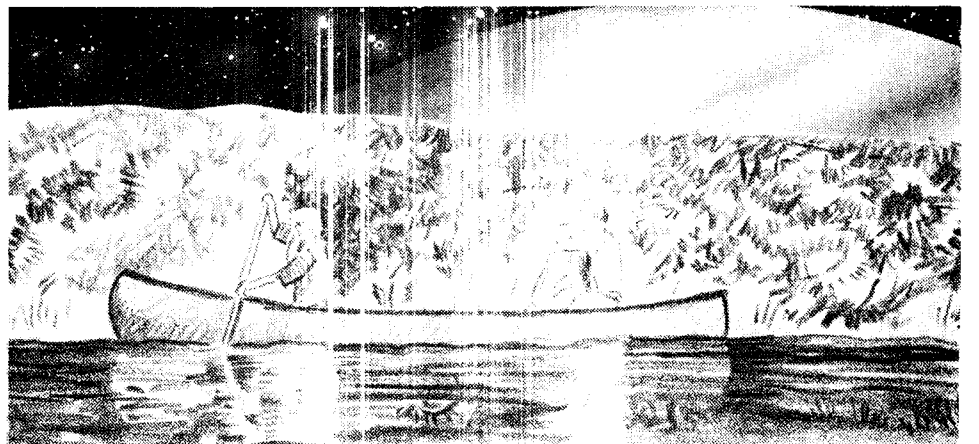

Bud Sparhawk

DAD

"Childhood, we're told, should be a time of innocence. . . ."

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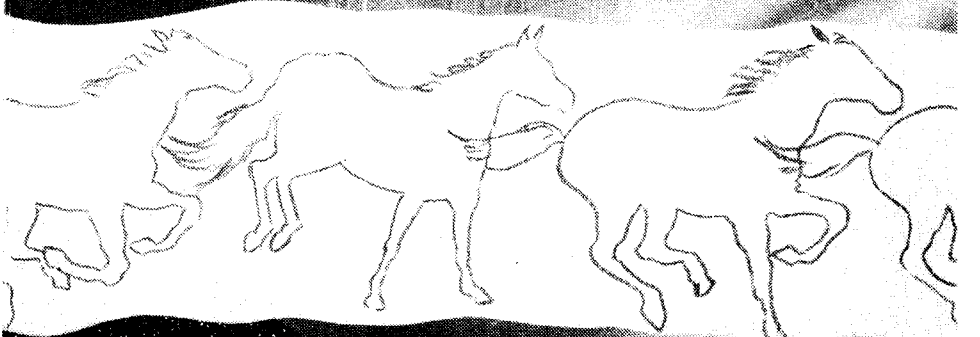

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It had been a glorious break after the planting of the spring crops. Dad and me had dragged the canoe fifteen miles up the river on the pack horse and put it in on a rocky promontory where the river gurgled over a series of riffles before forming a wide basin. We were taking two days away from the chores to meander downstream over the best rapids in the territory, or so I considered them at the time; my fourteen years of life had not given me that much experience, to tell the truth.

The weather was perfect. The air temperature was warm enough that you didn't need even a sweater, as long as you were in the sun, that is. The water was chilly from the snow melt higher up in the mountains. You could feel it through the thin plastic bottoms of your shoes. The sky was a beautiful deep blue, dotted with masses of cloud that drifted lazily across the sky. When I looked at one cloud that looked like a starship to my adolescent eyes, I felt a sharp stab of pain inside my head and stumbled, nearly dropping the pack I was carrying.

"You all right?" Dad asked. He was carrying the food bag, tent, and his own pack, and still was able to steady me on the rough footing.

"Sure," I said, not wanting a little headache to upset our plans.

We got the gear stowed and balanced in the canoe, putting most of the weight forward with me to counterbalance Dad's heavier mass in the stern. Later in the day we would reverse the canoe so I could steer, the first time Dad had let me do that.

Dad turned the horses loose and put the traces by the side of the path. One of the neighbors would find them and return them home. That's the way our little community worked, with everyone looking out for the others. The horses were pretty old; used to their regular feed and sheltered barn. They would amble home without any help whatsoever, having done it many times before.

We went through the first mile without incident, getting used to the feel of the water and the way the canoe reacted to our every motion. I was too preoccupied with handling the canoe to notice the wildlife along the banks, despite Dad's repeated attempts. According to him I missed seeing beavers, a bear, a fox staggering home after a rough night, and numerous water turtles and birds. I did see a fish gliding through the shallows, long and silver, sleek as a starship. Without warning the headache struck again. My paddle missed the stroke, sending a shower of water toward the stern. "What's the matter with you?" he yelled, and sent a spray in return.

When I didn't laugh his voice got real serious, "Is something wrong, Jimmy?"

"Yeah, I been having these headaches all morning," I said. "I guess I didn't get enough sleep last night."

"I wouldn't wonder, with the way you get excited about these trips." Dad always seemed to know about things like that, sort of like he knew what I was thinking most of the time.

I didn't have any more headaches that day, even when we came

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through a cut in some granite outcroppings that funneled the entire river through a narrow gap that dropped six feet into a pool. For one instant I was suspended above the raging waters and then dropped like a rock into the catchbasin below, making my jaw teeth slam together. We hit hard but managed to stay upright. Dad brought us around in a sweeping curve so we could admire the fall we'd mastered.

We went through a dozen or so small rapids after that, nothing special. And then, at the very end of the day, we came to a place where the river widened over a long, dropping fault sitting slantwise across the river. The softer parts of the fault line had washed away over the years leaving a maze of passages that defied solution. Back and forth we went, trying to find a passage down the slope. By the time we got to the bottom we were laughing so hard that we couldn't stop. We beached on an outcropping and I jumped out into the shallow water to pull the canoe up. Only the water wasn't shallow at all and I went completely over my head into the river.

It was such a surprise that I couldn't understand what had happened. I imagined that night had suddenly fallen and stars appeared before my eyes. That's when the headache struck again. Then I regained my bearings and came sputtering and gulping to the surface. Dad reached down with one rough hand and pulled me onto the rocks. We decided to make camp near there and warm up around a nice fire.

That night we stretched my wet clothes over the canoe so they would catch the radiating heat of the campfire. As always we just sat and enjoyed each other's company, not talking much. I tried to get Dad to tell me about the ship, how it crashed and all. He didn't like bringing that up, even though he'd taught me every control on it. If his ship were still around I'd probably be able to operate it myself, I'd learned so much from Dad's manuals and books. Imagine that, me a starship pilot! For a moment I regretted its loss, years before I was born.

Finally the fire burned down to embers, and our infrequent conversation turned to the adventures we'd have the next day. There were some good rapids ahead, including a series of riffles that we'd never been able to defeat.

The next morning the headache returned as soon as I got out of my sleeping bag. Dad was acting real concerned now, fussing with the camp gear and getting the canoe ready to go. He wouldn't let me touch anything, just made me lay there on my opened sleeping bag while he did all the work. I mean, the headache wasn't that bad!

"Are you seeing things?" he asked, real concerned like. Dad had always been real sensitive to things that were bothering me.

"You mean like hallucinations?" I asked. Boy, was there something he knew about and I didn't, a disease or something they'd kept from us all these years? Maybe it was what killed off the rest of the ship survivors in that first year. I could feel the sweat

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popping on my head. I might die!

"More like seeing the world different," he said as he folded the tent into it's little pouch. "Do the trees look the same?"

I looked at the trees. They didn't look too different, but were those leaves always that shade of green? Was the bark always that rough? I had never noticed how the leaves were stuck on the limbs—were they different now? All of a sudden the whole world started to appear real strange, like I'd never seen it before. Rocks, dirt, bushes, birds, even the river was strange to my eyes. I quickly turned to Dad, certain that imminent death was on its way.

"Don't panic, Jimmy. Everything looks strange once you really pay attention to it." He paused to reflect for a moment. "No, I was talking about seeing things that aren't usually there—or not seeing things that are supposed to be there. Strange shapes in the sky, for example."

I thought long and hard. Everything seemed to be all right. "No," I said.

"Good, let's get this canoe pushed off so we can get back to Mom's good food. You might just need a little rest." That's what he said, but I could tell that he was really worried, biting his lip like that. He didn't even complain whenever I let the bow drift off course.

Dad was unusually silent all the way home. Since the river wound back and forth through the valley the trip was nearly three times the distance we had traveled over the road. He took the easy ways through the rapids, avoiding the hydraulics that usually gave the two of us such a thrill. He avoided the side channels we usually explored and headed straight down the center of the river, going for speed instead of fun. Somehow I knew that it was more than a simple headache that was driving him home. That really got me worried.

As soon as we got close to the house I saw Mom coming toward us. From the look on her face I knew that something was wrong. She went straight to Dad, "Will," she said with a worried note in her voice, "We've got a visitor."

A visitor! We hadn't seen a stranger here since I was born. Dad said that our group were the only survivors. There just wasn't any place for this stranger to come from, not on the entire world. A sudden thrill went through my head—maybe this was a starman who had come to rescue us! I tried to look past Mom to see if he had the silver suit and helmet of the starmen of my books. Dad grabbed my shoulder and turned me around to face him.

The smile that had been on Dad's face had been replaced by a hard expression that I only saw once before—when the dog had died. That made me real sad; it was the first time that anything I loved had died. A few days later he wore the same expression when he told me that Pete was sick and his folks would have to take him away. Neither Peter nor his family ever came back. I guess they died too.

"Jimmy, run out to the barn and see if the horses are all right," he said. "Then run over to the Cassidy's and

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play with George until I call you home." I knew when to argue and when to just shut up and do as he says, so I did.

George was my best friend ever since Peter had gone away. He was sort of slow on the uptake, something the adults told me I shouldn't take much note of even if it did get on my nerves sometimes. It didn't take a lot of convincing for George to agree to sneaking back to the farm with me, even if he did drag his feet the whole way. We came through the woods, along the stream bed, and crawled up the little rise behind the house. Real careful like I stood on tiptoe and peeked into the living room where Dad and Mom were talking to the stranger. He wasn't much to look at. Brown hair, average-sized adult, dressed in farmer's duds, the same kind that all the men in the community wore (Darn, no silver suit!). They were talking so low that I couldn't hear them through the glass.

George tugged at my leg. "What's going on? Who is it?"

"I don't know. I never saw him before," I whispered, and shook off his hands. "We need to get some place where we can hear what they're saying." When the adults started talking real quiet you could bet that it was something that they didn't want the kids to know about, like when Pete had gone. This had to be interesting. I dropped back down to kneel with George.

"They're sitting by the fireplace, so maybe if we could get up on the roof we could listen in through the chimney." Last summer I had been on the roof fixing the packing around the chimney and heard Mom downstairs singing to herself, just like I was right next to her. "Give me a boost up," George made a stirrup with his hands and lifted me enough to reach the top of the tool shed and clamber up. From there it was an easy climb to the chimney. George scrambled alongside after I gave him a hand up.

"... necessary," I heard the stranger say. He spoke quickly, with different inflections on the words, an accent I guess you'd call it. "The damage was significant."

"So extraction isn't going to be easy," Mom replied in a worried voice. "When I think of all we've gone through—"

"Easy, Mary," Dad said. I could just picture his rough hands touching Mom on the shoulder. "We've got to think of how to bring everything down uniformly, otherwise the shock would be too great. How long will it take to get the whole community out?" he asked.

There was a long pause, too long. Finally the stranger said, "We aren't talking about the whole community. Just two people."

"I don't understand," Mom said. "Why can't all of us be extracted? Why are you being so selective?"

"Landrow," the stranger said. I heard Dad gasp.

"Mary," I heard his voice take on a husky tone that I'd never heard before. "All the exploration ships carry the Landrow capacity. It's a sort of survival device for the crew. A place they can keep their minds alive while they wait for rescue."

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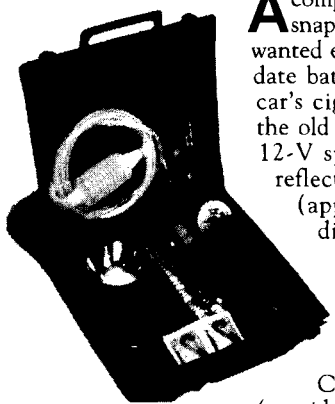

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The stranger's voice cut in, firing off technical jargon with such speed that I could barely understand him. "... preservation mechanism that ... allows storage of personal memories ... virtual environmental reality capability ... allows invention of artificial worlds. We can ... and build the body back but ..." and on and on. Apparently there was something in the ship that was keeping the crew alive, he had said, but the crew was us, the community. What was going on here?

Then Mom asked something that I never expected, "What about the children?" Dad and the stranger harumped a lot before Dad answered, "There weren't any children on the ship, Mary. There was just the crew."

"I don't understand," she said plaintively and listed the names of all the kids in the community, "What about Pete, and George, and Dick, Jean, Phil? What about Jimmy?" she finished with rising panic in her voice. Suddenly I knew what they were saying. I knew what all of us kids were and what was about to happen.

I grabbed George and slid down the roof, hitting the back side of the slope and taking off like the hounds of hell were on my heels. George was puffing right behind me. We ran until we got to the river, where Dad had left the canoe and all of our camping stuff. I didn't wait for explanations. I just grabbed the end and pushed it into the water. "Jump in," I yelled, and picked up the paddle as the current grabbed hold. George scrambled into the bow seat and picked up the other paddle. Within a few minutes we were around the bend and out of sight of the farmhouse.

"What's happening?" George asked when I'd stopped paddling like a fiend. "What were they saying about no kids?"

I tried to reason it out in my own head. Dad's manuals showed that the Landrows were more than just a survival capsule. Even with the best of technology there was simply no way that a starship crew's bodies could last long enough to be rescued. No, technology of the late twenty-first century had devised a better way and focused on saving the individual's unique identity, the ego, the soul, whatever you want to call it.

A Landrow unit was a complex computer storage unit that held the crews' memories, emotions, and thinking process in storage while their bodies went the way of all flesh. Because no mind can remain sane or even sentient without stimulation, the Landrow would constantly refresh the mental landscape, provide a virtual environment in which the mind could roam and grow, much like the real world.

Nobody really understood the workings of the Landrow units. It was much like the neural networks of the last century where everything was understood at every level but nobody could determine what was happening at the quantum levels where decisions were reached. The mechanics of the unit were straightforward. The nanomachines were well understood. Amorphous memory was standard industrial stuff, guaranteed for eternity, plus one day. Yet nobody had a working model of how all of these com-

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bined to produce the results that were clearly demonstrable.

"The adults are the crew of the starship," I said by way of explanation.

"Shoot, everybody knows that."

I hesitated to tell George what I had figured out in that instant on the roof. If the ship had crashed and the crew had submitted themselves to the Landrow then all of this, all the world we knew, was just a simulation. We were all just a machine's way of trying to keep a few people sane until help could arrive. Maybe that's why Dad wouldn't talk about the ship. Maybe he was the pilot who crashed it and killed the passengers. Yeah, that's it. He crashed it and survived in the Landrow with Mom and a few others, probably George's parents and the rest of the community.

"The crew didn't have any kids with them. The stranger said that there were no children on board!"

George was puzzled. "I know that. We were born afterwards. After the farms were finished."

"But if the crew was in the Landrow units then they couldn't have kids," I said, trying to figure it out myself as much as explain it to George. "The farms, the families, the buildings, everything in the whole world is just computer pictures."

"You mean like the units at school?" George asked.

Now that he mentioned it, it was strange that the school computers should survive while the rest of the ship was gone. Now that I thought about it where did all of the stuff we had come from? I thought about the starship specifications that I knew so well; there was enough room for crew, maybe ten at most, and some frozen passengers, maybe a hundred or so. Then there were the stores; seed and embryos for the most part. Nonessential goods couldn't be carried, like this canoe we were paddling down the river. As I reasoned through the evidence the conclusion that this was all a simulation became clearer and clearer.

"The stranger said they were going to revive the crew. That means that the adults will start to wake up and when they do the world will start to come apart. If your folks don't need the farm then the farm will disappear, buildings and all."

George's voice raised to a plaintive wail, "But where will I live if the farm is gone?"

"You won't, George. You're part of their simulation. You aren't real like they are; you're just a simulation to keep them sane." I didn't add that I too would disappear when Dad and Mom were revived. My head was throbbing now. The more I thought about it the worse the headache seemed to grow.

All of a sudden I understood why I had these feelings of not belonging. Of being different in some strange way from all those around me. It explained why the adults were always so knowing and confident. Why they behaved so strangely sometimes, although I couldn't understand why —like Dad and Mom going off by themselves in the middle of the day sometimes, Dad with a goofy look on his face when they returned. Now it

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made sense; a simulation wouldn't understand. A simulation like me didn't need to know all those things. It would just have to know how to behave like a kid, not even a real kid at that, just enough to satisfy the adults.

There was a break in the tree line ahead, indicating a side channel. I pulled the canoe under the dark shade of overhanging limbs and carefully steered the canoe farther from the river. We could stop here and rest, maybe enough to get rid of this headache. Yeah, and in an hour or two we would plan our next steps. I hoped that Dad and Mom still had enough affection for me that they wouldn't terminate the simulation without saying goodbye, and the longer that took the longer I had to think of some way out of this fix. I prayed real hard that I was right about Dad.

Dad and the stranger found us later that evening, coming over the ridge behind us and sitting down at the fire as if this were an everyday event. The headaches hadn't stopped even though I'd rested with a wet cloth on my head.

"This is Captain Harris," Dad said by way of introduction. "He has a starship in orbit nearby." The news would have been stunning if I hadn't figured it out already. Who else could it be on this remote world?

"Hello Jimmy," the captain said with that funny accent of his. There was a note of real sadness in his voice, like he was carrying bad news. "Your dad's been telling me about your life here. I sure wish I had a world as nice as this to grow up in."

"It's OK," I replied. Why did he tell me how nice this was if they were going to take it all away? Didn't the adults understand that us simulations had feelings too? "I know why you're here," I said; no sense beating around the bush.

Dad and the captain looked at each other with one of those funny adult expressions before Captain Harris spoke again. "I'd like to tell you a story about a boy I once knew," he began. Why do adults have to tell stories to explain things? Why can't they just say what they mean and be done with it?

"He was named James, too. James grew up in a place very different from this. It was an industrial part of old Earth before the separation. James's life was very hard. His father ran away when he was twelve. His mother did a lot of ugly things to keep money in the house and, when he was about your age, she died of an overdose. He learned to avoid the gangs that controlled his neighborhood and kept trying to recruit him. He learned how to avoid letting any of the sewage and filth in the streets infect him. And he learned that the easy money that he could make in the factories was a trap that was almost too easy to fall into. Best of all he learned, and learned until he was the best and brightest in his school. And do you know why he did these things?"

I nodded, interested in spite of myself.

"Well, James had a dream. He wanted to grow up to be a pilot of a starship. He wanted to get enough

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education to earn a billet in one of the high cities. He wanted to stay healthy enough that he could pass the physicals. And he wanted to stay clear of the law so he could have a clean record to pass immigration.

"Well, James finally got to the high cities and started to get a real education. That's where they discovered his talent: He was one of the 1 percent of ½ percent of trainees that had the reactions and the instincts to manage a starship moving at nine-tenths the speed of light at emergence from Tau space. It took him nearly five years of very hard work to learn how to harness these natural gifts before they let him take a ship out."

"Where did he go?" I asked. James sounded like the pilot I wanted to be.

"Oh, lots of places. Wherever the pioneers were sent. Wherever a colony needed some critical element they had overlooked in their planning. He made a half dozen trips before his last one."

The headache had returned, worse this time than ever before. "What happened to him?"

"We're waiting for him to tell us himself, but, as best we can figure, he made a terrible miscalculation and hard-landed the ship on a planet."

Now I was certain. He was telling me about Dad and how he crashed the ship, somewhere right on this world, he said. But where? I had never seen it and had never heard anybody mention it. The headache stabbed again; maybe the simulation didn't need a ship as a reminder.

"The planet wasn't like this one," Captain Harris said as he waved his hand around to encompass the woods, the river, and the mountains. "James's ship crashed on a Class Two planet. It was barren of life, had a reducing atmosphere and excessive gravity. Place was useless to everyone and everything.

"Well, after the crash it was pretty obvious that those who'd survived this far weren't going to live much longer. The landing had separated the cargo hold and spread the passengers and goods over a hundred miles of ravines and craters. The life support was in fair shape, probably held several days worth of air. Three of the crew were dead, crushed when the ship impacted a large boulder. That left just three alive enough to climb into the Landrows: James the pilot; Peter, the navigator; and Mary, the astrogator."

As I suspected, it was Dad, Mom, and somebody else—probably George's father. At that moment I knew the rest of the community, not just the kids, were simulations as well.

"From the records we found it looks as if Mary had to force James into the unit; he left a testimony stating it was entirely his fault that the ship had been lost. We have no reason to doubt his words."

I felt a pang of fear go through me. Dad was the one who crashed the ship. Dad was the pilot they were talking about. Dad was the one they would blame for all those lost colonists. Please, make it not true, I thought. Make all of this some mistake. I might be just a simulation but

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I still loved Dad. He had given me everything he could; treated me as he would a real child of his.

I thought of the control panel on the ship; every button and display clear in my mind's eye. I imagined I could see the data peak as the ship rose out of deep Tau and made the few atoms per cubic light-year glow red as we entered normal space. The scenes now came unbidden into my head, unfolding like a filmed drama: The stellar disk off the bow where it had no right to be; the twisting of space as the ship stressed in the gravity fields and sped toward the star.

Quickly, the images rolled on; careening across the system, looking for someplace to dump our inertia, trying to find a gravity well that... There it was, a planetary mass! In an instant I warped the ship planetward trying to hit an insertion path —maybe a long elliptical. Everything was happening so fast: less than thirty seconds had elapsed since emergence. The insertion was wrong, so wrong, and in seconds we hit the hard atmosphere, tearing away the external framework with a scream of metal. Then it was tumble, spin, and thrash. No hope of control. No aerodynamics to help us. I had failed, the ship would be lost. And all the souls as well. Welcome blackness closed in.

Mary was stuffing Peter into the Landrow bag and activating it when I got back to the control cab. My quick examination had shown that the rest of the crew—Dick, Jean, and Phil—were beyond help, three more deaths to add to my list, I thought.

"You're next," Mary said, as she pulled another Landrow from its perch in the emergency locker. "Let's get this over with."

"Let me help you," I said and moved to take the bag from her hands. "As captain I should be the last." Peter's bag was heaving and thrashing as his shape diminished. In another few moments he would be safe.

"No way," Mary replied, pulling the bag back. "You're in no shape to make a rational decision about putting yourself in the unit. I want to make sure that you're still around when I get back." Good old Mary, she was the senior member of the crew and mothered us all.

Neither was I in a condition to talk her out of it. I was still numb over the needless loss of life and property—all my fault, my responsibility, my doing. I dictated a permanent record, lay back and welcomed the enfolding maw of the Landrow.

"Now you're beginning to understand," Bill Harris said. His name came easily to my mind. "We wondered why you had done this to yourself."

"I...I don't understand," I stuttered. How had Dad's thoughts entered my head? Was he trying to make me understand what he felt like? Was he using the Landrow to give me a sense of why he had retreated into this artificial world so unlike the one he grew up in? It didn't make me more comfortable about my own situation, but I did understand Dad's.

"Thanks Dad. I guess you can turn me off now. I guess that you and Mom have got to get back to the real world and deal with the problems you've avoided all these years." I couldn't hold back the tears any more. Simula-

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tion or not I still hurt about losing everything I knew and loved. I reached out to hug Dad and felt his strong arms close around me.

"I love you, too," he said with a gruffness in his voice.

Harris stood up and stared at the pair for a moment. "It's time to go, Jimmy. The emergence team is ready to start the extraction."

"Goodbye, Dad," I said. I tried to sound manly but my voice cracked at the last and the tears started to roll down my face again. "You know how much I love you. Please don't forget me. Promise you won't forget me," I pleaded.

Dad just looked at me with a hint of sadness and pain in those brown eyes of his. "I'm sorry, Jimmy, but I can't do that. After this I'll probably never think about you again. Nor will Mom," he added softly and turned toward Harris. "Will you give me enough time to get back to the house so I can be with Mary?"

Captain Bill Harris nodded and reached out a hand to me. "Come along, Jimmy, let's give you one more canoe ride." I watched Dad's receding back as he climbed the ridge toward home. Silently Bill and I pushed the canoe into the water. "Will it hurt?" I asked. "When they start the 'extraction,' I mean."

"The pain will mostly be the return to the real world with all of its responsibilities and cares. Physically, it will be uncomfortable. Mentally, leaving all of this for someplace harsher and harder, it's going to be very difficult. But I think you can make the adjustment, now that you're starting to remember your real self."

For a moment the words didn't make an impact. *I* could make the adjustment? *My* real self? What was he talking about?

"You shouldn't blame yourself, you know," Bill said as he dipped his paddle into the swiftly flowing river, pulling back with a powerful J-stroke that I had taught him years ago. "Retreat from responsibility is a classic move for pilots in these situations."

Yeah, I remembered that from class, too. I glanced down and noticed that I had suddenly acquired Dad's rough brown hands. And his arms as well! With surprise I noticed that my fourteen-year old's body had changed into a full-grown man's. I now looked exactly like Dad.

"We were too late to save Pete, you know. The crash did something to his Landrow that made it malfunction about two years ago. I'm afraid that we lost him."

I suddenly realized that George had wandered off somewhere during my parting with "Dad." Of course, George *was* a simulation, a fragment of my imagination, just like the rest of this pleasant world, so unlike the one I grew up in. As I thought about it the memories of James's life ran through my head. I remembered all the pain and longing for family and stability. All the need for a life easier and filled with love.

"And now you have it," Bill said, obviously they were monitoring my thoughts. "You've finally had the boyhood that you never had in real life. Is that going to make you happy?"

"Happy?" I asked, and thought of Dad . . . with Mom . . . back home on the farm. ■

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This science fictional vision of space travel is nearing reality. By the time this issue of *Analog* (June 1993) is on the stands in April 1993, a one-third scale version of this spaceship may be undergoing its scheduled suborbital paces above the high desert country of southern New Mexico, at the White Sands Space Harbor near Alamogordo. In planning for several years, the project is now called "Single Stage Rocket Technology," SSRT, and the demonstration craft itself is the *DC-X*. The new vehicle must demonstrate successfully the elements required of a full-scale follow-on orbital vehicle: new materials technologies, complex aerodynamic maneuvering capabilities, sophisticated guidance and flight controls, and the economies of airplane-like ground operations. With successful tests and appropriate funding, a Single Stage To Orbit (SSTO) prototype version, the *DC-Y*, a ship capable of crewed or uncrewed flight, could be flying within another 600 days. The fully-operational version of this craft, a true spaceship capable of single stage flight to low Earth orbit, return and vertical landing, will be called the *Delta Clipper*.

The Pride and the Problem

Five days after the 1992 World Science Fiction convention in Florida, a NASA engineer gave my wife Joyce and me a personal VIP tour of Kennedy Space Center, where we observed the intricate preparations for the maiden flight of the space shuttle *Endeavour*. The next day *Endeavour* launched precisely on time in a earth-thundering performance, and performed its mission with few problems; I would have loved to go. Nevertheless, the pageant of this magnificent flight saddened me, because the cost of four of these impressive launches could pay for a fleet of several Delta Clipper SSTO vehicles. Then, for the cost of *one* shuttle launch, these Clippers could fly into orbit *50 to 100 times*, taking up many satellites or even thousands of us ordinary people—businesspeople, SF fans, *tourists!*—not merely the few highly-trained astronauts who now travel at such great expense.

The Space Transportation System (STS) comprises the space shuttle and a "standing army" (in the words of pioneer aerospace designer Maxwell Hunter) of between 9,000 and 15,000 people who operate it—the managers, engineers, technicians and scientists who maintain, repair, refurbish, rebuild, mate, load, carry, fuel, launch, retrieve, inspect and transport the billion-dollar craft that, by

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U.S. standards, are the only man-rated spaceships in the world. Compromises in the initial concept of fully-reusable space transportation system drove the shuttle costs to an estimated $500 million to $1 billion per launch; the actual amount is not even accountable in government records. Of the millions of pounds of weight lifted from the pad, only the crew returns totally reusable; the large external tank burns up on reentry, the solid rocket boosters must be retrieved and rebuilt, the shuttle craft itself must be inspected and refurbished over several months. Much of the weight of the orbiter lies within the large wings of the ship; these appendages were added as a military requirement in the early days of the project when much more reentry flying flexibility was expected of the design. As every SF fan knows, wings are worse than useless in space, adding extra weight and structure to an already massive system. With commercial satellites removed from the NASA manifest after the *Challenger* catastrophe, embarrassed NASA crews now often fly with half-empty cargo bays.

The Reality

As the *Endeavour* vanished into the clear Florida sky, and as the many thousands of shuttle support people turned to other work to prepare the next shuttle flight, I thought about the *two* Air Force officers who were overseeing the entire SSRT/SSTO project and the *six* people in a makeshift control center who would launch their revolutionary craft at White Sands seven months later. In a way, watching the shuttle was like witnessing the majesty of a great dinosaur, a beast marvelous to behold, but one whose time had passed. With the changes in the political winds—this is being written the day after Election Day, 1992—the whole environment for support of space travel is shifting. The tremendous costs for questionable technical achievements in space and science may not be borne by a population concerned more about jobs and health care.

We should learn a lesson from our predecessor species: large, cumbersome, inefficient creatures do not survive traumatic changes in the environment. The dinosaurs died after a great environmental shock by a meteor; the shuttle program may face an equally devastating budget blow from a nervous Congress. In such conditions only the small, efficient organisms survive. And not all survival skills are technological; as our distant ancestors—the tiny mammals who once hid from the giant reptiles—discovered, finding one's ecological niche is paramount. By analogy, the small SSRT/SSTO project may be the most likely evolutionary successor to the gigantic shuttle program.

A Short History of Rocketry: The Ammunition Syndrome

How did we come to have an expensive shuttle and not a cost-effective SSTO? The answer may lie in tradition. Except for a few early experiments and some specialized pilotless craft, most full-sized airplanes

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have been designed to *carry* people. On the other hand, from early China to the Persian Gulf, from gunpowder-burning missiles to V2s and Scuds, rockets were usually designed to *kill* people. According to Max Hunter, this mind-set has carried over, unfortunately, into the design of today's rocket-propelled spaceships. They are not designed for *transportation* as airplanes are, he says, they are to be used once, regardless of cost, and then written off. Rocketships are considered *ammunition*.

History has borne out Hunter's contention. The German designers who built the world's first vertically-launched manned rocket vehicle, the *Netter,* at least attempted to retrieve the most valuable components of their rocket interceptor system. The liquid-fueled craft was intended to break up into recoverable segments when its fuel was spent, parachuting both the pilot and the expensive rocket engine back to Earth. The first man to be so launched by rocket, one Lieutenant Sieber, died in the first test flight in 1945. We haven't done much better since. Cosmonauts had to parachute from their early space capsules shortly before impact; our own *Mercury*, *Gemini* and *Apollo* astronauts had to bring down their capsules by parachute onto the relatively soft ocean surface. Only the human crew and a small amount of instrumentation were recovered after a flight; the propellants, the rocket craft, the fuel tanks, the electronics, the rocket engines, were all thrown away, the capsules no longer usable by design. Even today the successful space shuttle brings back only the crew and the ship. And the "standing army," to use Hunter's term, those thousands of highly-skilled, highly-paid technical people, stay on the payroll regardless of the number of launches.

Astronautical Absurdity Accentuated: Alternate Airplanes

What if airplanes had evolved the same way, like ammunition, such that even the most efficient jet airliners dropped off their engines along the way, that any given aircraft could only be used three or four times per year, and then only with thousands of technicians servicing it? Under these conditions, what would your flight to Hawaii cost, or your trip to Grandma's down in Florida? The answer is—you wouldn't be going at all. And though they are cheaper to launch, today's expendable launch vehicles—ELV's—are even worse in principle. Imagine flying a pilotless aircraft to Cleveland, unloading the cargo, and then ditching the whole airplane! With an airplane transportation system like that, you would never get a Federal Express delivery system. (Now the U. S. Postal Service, you might get. . . .)

Obviously, with such a wasteful airplane transportation system we wouldn't have the thousands of relatively inexpensive flights that take us all over the world daily. By direct comparison, the nation cannot afford such a wasteful method for space transportation either, not for anything less than national survival. And with the apparent end of the Cold War, even that reason has less claim

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on the country's budget.

Now For Something Completely Different

Even before the first space shuttle flew, private interests and government planners realized that the prohibitive expense of the enormous shuttle program would not enable the United States to access space economically and reliably. By the middle of the last decade the concept of the Single Stage To Orbit system emerged as perhaps the nation's best chance to get on with cost-effective space exploration and exploitation. The SSTO evolved by comparing space vehicles to airplanes: airlines make money by turning their airplanes around quickly between flights and by carrying cargo and passengers safely and reliably almost anywhere, almost any time, using a standard "infrastructure" of airports for takeoffs and landings. Max Hunter thought that true spaceships should do the same.

Aerospatiale notwithstanding, the United States is still the most effective designer and producer of aircraft *transportation systems* in the world; we make enormous amounts of money building, selling, and using airplanes. According to Hunter's figures, the average jet airliner requires a crew of about 150 people—mechanics, technicians, clerks, flight attendants, pilots, ticket-takers, and baggage-handlers. Turn-around time between flights is a matter of minutes. Even fighter aircraft, for all their sophisticated technical systems and avionics, are supported by less than 50 personnel each. In the late 1980s Max Hunter, Jerry Pournelle, Gary Hudson and others proposed an SSTO designed for economic airline-like operations, one that would be maintained and operated much like an airplane, with a minimum crew and with minimal investment in launching and landing facilities. Hunter argued that commercial air travel had been "man-, woman-, and child-rated" for over 50 years, and that SSTO spacecraft should be designed, built, tested, and certified the same way for civilian use. (A fictional version of Hudson's SSTO appears in the novel *Fallen Angels*, by Jerry Pournelle, Larry Niven, and Michael Flynn.)

Technology Alone Is Not Enough...

Through Hunter's efforts, and with the political and technical support of Dr. Pournelle and his associates, both government and private studies concluded that newly available materials and technologies made an SSTO feasible. This information eventually led to a series of briefings of Washington policy makers. Eventually the Strategic Defense Initiative Organization, SDIO, needing cheap and reliable rockets for launching its payloads, agreed to fund four major aerospace industry teams to design an SSTO. Proposed designs included both winged and wingless craft, full rocket power and hybrid rocket/air-breathing propulsion. An independent review board selected the McDonnell-Douglas design for development. The company named their wingless, fully rocket-propelled prototype craft the DC-Y, or "Delta Clipper." Funding

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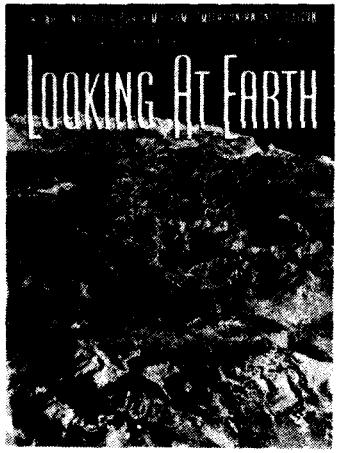

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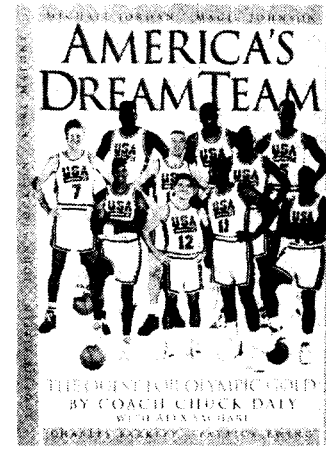

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was limited only to a proof-of-concept sub-orbital demonstration craft called the DC-X, but it was the first step toward an SSTO.

. . . But It Is Necessary

Max Hunter's insistence on airplane-like maintenance and handling is integral to the whole project, and true reusability and efficient operations are key economic factors in commercializing the SSTO. The SSTO design requirements capture this new philosophy:

1. The SSTO must launch 20,000 pounds in an easterly orbit with 600 feet per second velocity change while on-orbit (which translates into 10,000 pounds in low polar orbit).

2. The SSTO must be fully reusable; have a seven-day turnaround; require no more than 350 person-days maintenance between flights.

3. The SSTO must possess "Engine out, intact abort" capability; have at least a 15% weight margin; be unmanned with a manned option.

These criteria could not have been met in decades past. With the materials and rocket engines available in the 1960s, a single stage craft could only have flown the distance from New Mexico to Greenland. Even then, the weight of the necessary flight control computers, had they existed, would have been prohibitive. But since that time new advanced technologies have been developed that will enable an SSTO design to meet the original requirements. These advances include:

—unique and lightweight thermal protection systems

—advanced rocket engines and fuel storage systems

—sophisticated microcomputers and on-board avionics equipment

—light weight carbon composites and metal alloys for structures and fuel tanks

These technologies were invented for, and matured in, other government research and development programs such as the space shuttle, National Aerospace Plane (NASP), advanced fighter aircraft, and similar high-technology defense and aerospace projects. In accordance with their design philosophy, the DC-X team has adapted as much of this equipment, materials, and processes as possible, keeping new invention to a minimum while maintaining cost, reliability, and reuseability within pre-set targets. The overall performance goals of the SSTO project are shown in Figure 1.

Design For The Real World

The DC-X is built at the McDonnell-Douglas facility in Huntington Beach, California, using the latest off-the-shelf technologies. The project management style, however, dates from the 1940s, when Kelly Johnson's famous Lockheed "skunk works" revolutionized airplane design to produce, over the decades, the first U.S. mass production jet, then the U2, followed by the SR-71 "Blackbird," the F-117 Stealth fighter, and the still-under-wraps mystery plane, "Aurora." In modern industrial terminology, the term "Concurrent Engi-

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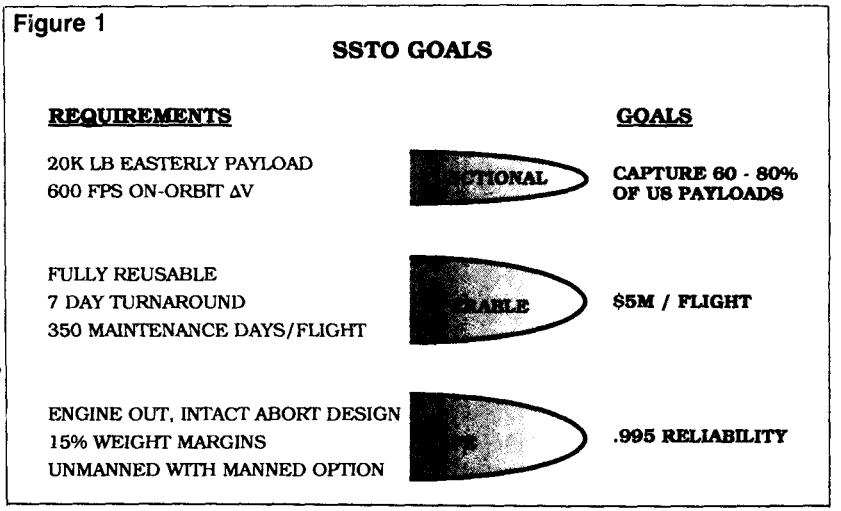
Figure 1



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neering" captures the same management philosophy, that of explicitly setting a realistic goal, dedicating the appropriate resources, and selecting the proper team. A Concurrent Engineering team does all of the necessary tasks *at the same time*, doing them right the first time, and avoiding all unnecessary bureaucratism. By managing the SSRT as an "advanced technology demonstrator," the DC-X concurrent engineering team has bypassed the Department of Defense's business-as-usual procurement process, allowing managers to implement a rapid program without the mountains of paperwork and hundreds of military officers often found in projects of similar scope and complexity.

The results of this integrated design approach are impressive. Figure 2 shows the basic structure and configuration of the DC-X. Every part of the vehicle is designed for ease of access for maintainability and repair. Standing 39 feet tall with a base diameter of 12 feet, the vehicle weighs about 21 tons at takeoff (including ten tons of fuel) and carries a test payload of 500 pounds. It features aluminum and steel fuel tanks and aluminum internal structures, built by Chicago Bridge and Iron. The hydraulic landing gear is furnished by MBB, a German firm with extensive experience in VTOL aircraft landing gear. Scaled Composites, a firm owned by Dick Rutan, the man who co-piloted his "Voyager" craft nonstop around the world, is building the graphite-epoxy aeroshell that forms the outer surface of the DC-X. The cone-sphere aerodynamic shape is taken from extensive data on successful Air Force maneuvering re-entry vehicles. Attitude control in flight is provided by gaseous oxygen (GO_2) and gaseous hydrogen (GH_2) thrusters. The four engines are taken from

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the very successful Delta rocket series—four RL-10s, off the shelf, modified for sea level start and for throttling. Fueled by liquid hydrogen (LH_2) with liquid oxygen (LO_2) as the oxidizer, the rocket engines of an SSRT/SSTO launch spew out mostly vaporized water vapor—*steam*—as benign a product of combustion as one would want.

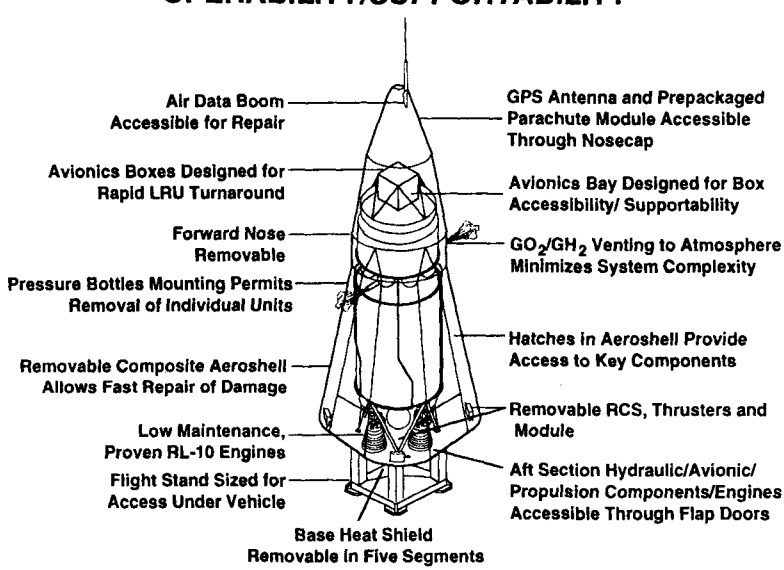
Tests and Evaluations: Technology and Politics

Because the SSRT/SSTO program is presently constrained to a preliminary demonstration craft only, the future of the entire program rides on the results of the White Sands test. This approach has its critics within both government and industry. The DC-X, a "flying test bed" of available hardware built with existing technologies, does not address all of the problems a full-scale orbital vehicle will encounter. Because the vehicle is not designed for operation in space or for high-speed reentry, and because it does not have the new engines or thermal systems necessary for such capabilities, some critics have called it merely a "stunt," a "flying fuel tank." But the DC-X team realizes that in the real world of politics and government funding, realistic progress requires one small step at a time, an incremental "pay as you go" approach.

Regardless of the criticisms, the

Figure 2

DC-X FLIGHT VEHICLE DESIGN EMPHASIZES OPERABILITY/SUPPORTABILITY


Air Data Boom Accessible for Repair
Avionics Boxes Designed for Rapid LRU Turnaround
Forward Nose Removable
Pressure Bottles Mounting Permits Removal of Individual Units
Removable Composite Aeroshell Allows Fast Repair of Damage
Low Maintenance, Proven RL-10 Engines
Flight Stand Sized for Access Under Vehicle
Base Heat Shield Removable in Five Segments
GPS Antenna and Prepackaged Parachute Module Accessible Through Nosecap
Avionics Bay Designed for Box Accessibility/ Supportability
GO_2/GH_2 Venting to Atmosphere Minimizes System Complexity
Hatches in Aeroshell Provide Access to Key Components
Removable RCS, Thrusters and Module
Aft Section Hydraulic/Avionic/ Propulsion Components/Engines Accessible Through Flap Doors

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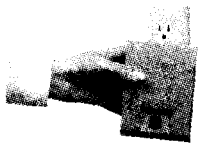

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DC-X team intends to fly their machine and to learn as much as possible that can be transformed to the future design of the orbital vehicle, the DC-Y. This includes drastically lowering the cost of handling and operations. Figure 3 illustrates the simplicity of the operation, a DC-X being towed to the launch stand on a standard transporter, by a conventional airport tow truck with only one driver. (Compare this to the massive football-field-sized shuttle transporter at Cape Canaveral and you will see the simplicity that results from the "bottom-line" design philosophy.)

Figure 4 illustrates the planned flight tests. In actuality, there will first be extensive flights at altitudes of 600 feet to test differential rocket engine throttling, the hovering capability, and the reaction control system (RCS) roll controls. Flights up to 5,000 feet altitude will determine the effects of high velocities and altitudes. Both of these early test series will bring back the DC-X to land within 500 feet of the launch pad, where data will be gathered on the effects of interaction between the exhaust plume and the ground. Finally, the DC-X will be put through its paces up to 30,000 feet to test the aerodynamic lift capability that will enable the craft to fly under low power, and to demonstrate the complicated rotation maneuver needed for landing a DC-Y from orbit. In these tests the sub-orbital demonstrator will travel a mile down range and return to within 500 feet of the pad.

Figure 3

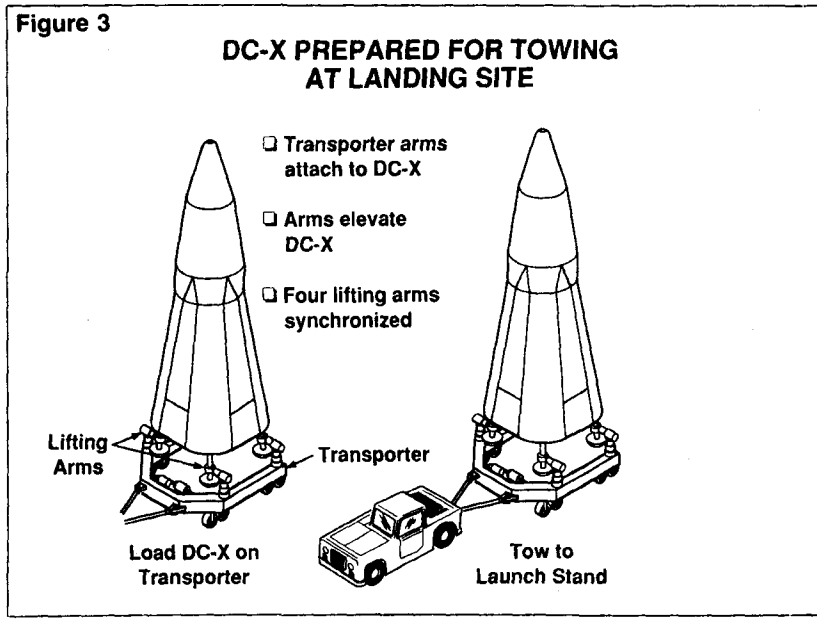
DC-X PREPARED FOR TOWING AT LANDING SITE
❑ Transporter arms attach to DC-X
❑ Arms elevate DC-X
❑ Four lifting arms synchronized
Lifting Arms
Transporter
Load DC-X on Transporter
Tow to Launch Stand

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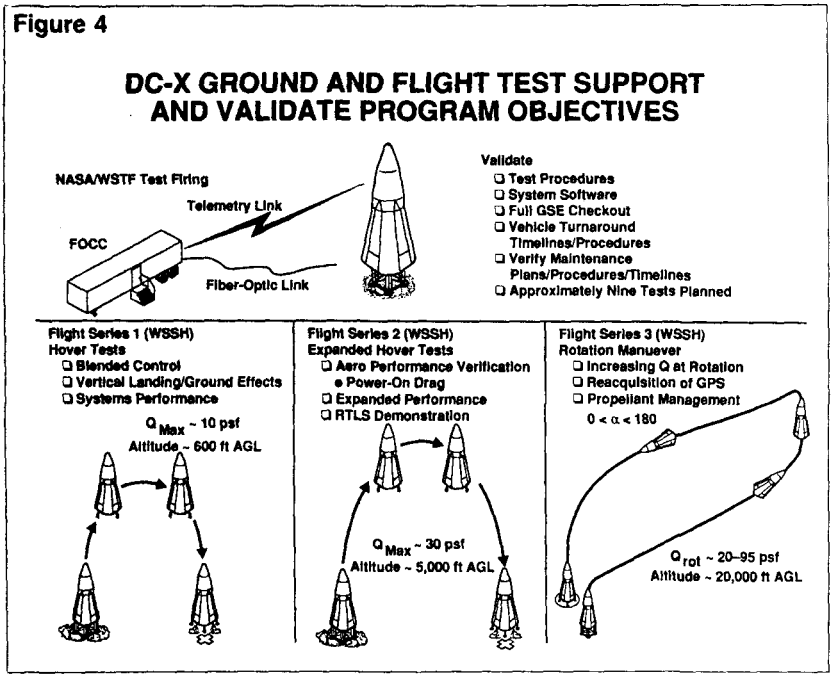
Figure 4



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The first DC-X will be flown from a "virtual cockpit" by veteran *Gemini* and *Apollo* astronaut Pete Conrad. Much like a video game simulation, Conrad will view the flight as if he were a pilot onboard and fly it accordingly. (It is rumored that Conrad wanted to be onboard to fly the craft physically, but that the 500-pound payload capability was already spoken for....) This new concept of piloting is expected to be applied as well to the DC-Y follow-on vehicle; both craft will fly as if a human pilot were on board, never knowing the difference. For the experimental flights, the entire blockhouse crew consists of only six people. For operational flights of a Delta Clipper, the software development terminal will not be in place; only three people will work the mission.

The DC-X program philosophy has already won its first victory: everyone involved in the test program is treating the rocket craft like an airplane, not like ammunition. White Sands Missile Range safety management, satisfied with the safety and reliability of the design, for the first time in WSMR history is allowing a test rocket to fly without an on-board command destruct system in place. (It has been pointed out that a hundred 747 aircraft fly near WSMR every day at 30,000 feet altitude, each hauling hundreds of people and thousands of gallons of inflammable fuel

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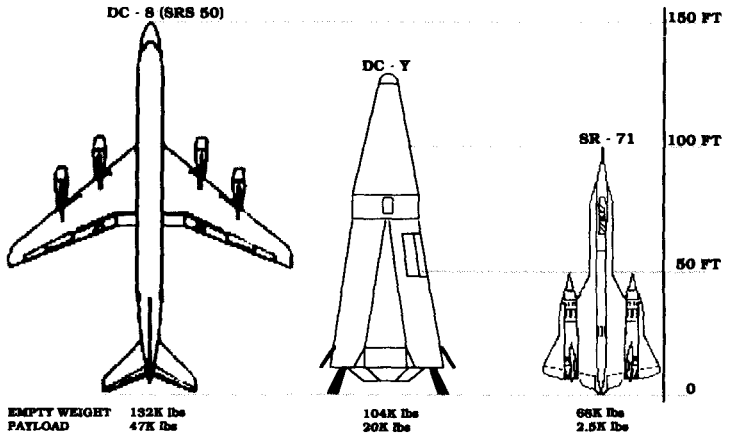
Figure 5



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over densely populated areas coast to coast, and that not one of them carries a command destruct system.)

The DC-Y: On To Orbit

Technologically and politically, the DC-X tests must demonstrate minimal facilities investment, responsive flight characteristics, high reliability, and overall low costs. Each of the demonstration tests is directly traceable to corresponding SSTO requirements. Assuming successful tests of the DC-X and ongoing funding for its successor, design on the DC-Y could begin while the WSMR tests are under way during the remainder of fiscal year 1993. The size and configuration of the proposed DC-Y orbital prototype are shown in Figure 5: somewhere between the length of the SR-71 Blackbird and a DC-8 airliner. The space ship (Figure 6) is approximately 130 feet tall, 40 feet in diameter at the base, weighs 1,300,000 pounds at lift-off, and carries about 20,000 pounds into low-Earth orbit. As with the DC-X, much of the hardware will be off-the-shelf and the rest will be designed by teams experienced with DC-X test results. Thermal protection systems will be similar to the technologies used in the shuttle tiles, though current projections may allow for blanketed, paneled, or sprayed-on materials instead of thermal tiles.

The complex rotation and descent trajectory must be solved by DC-X testing before the much larger DC-Y undertakes the same dynamic loading, a maneuver that has never been performed by a reentering vehicle. One flight test concern is to deter-

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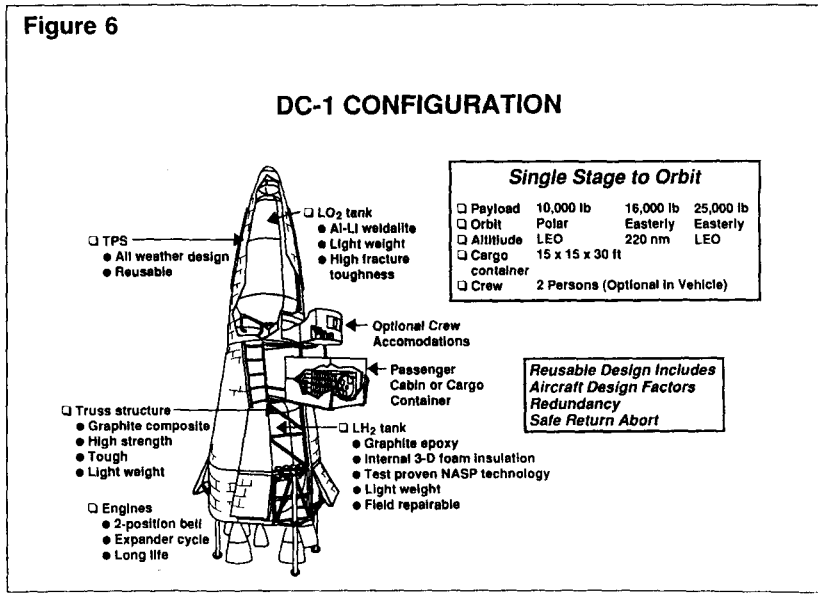
mine how to guarantee the "capture" of the sloshing liquid propellants during this high-stress rotation, so that the rocket engines can continue to operate as designed.

The primary technological uncertainty at present rests with the development of next-generation throttleable LH_2/LO_2 rocket engines that can operate at sea level and in space. Using eight of these engines, each with about the thrust of a space shuttle main engine, will give the DC-Y the capability either to abort the mission or to achieve low-Earth orbit even though one or more engines fails during ascent phase. The same reliability is required to guarantee safe landings from orbit, given similar engine failures while descending. SSTO designers are convinced that such engines can be developed; several design configurations are being theoretically evaluated now.

After exhaustive tests of the DC-Y configuration, including both crewed and uncrewed tests to orbit and back, all the evaluation data will be incorporated into the fleet of operational Delta Clippers, shown in Figure 7. The typical operational trajectory of a flight will carry the craft into orbit. After on-orbit operations, the spaceship will eventually return, flying up to 1,200 miles cross-range (sideways travel from point of reentry) utilizing its lifting-body-shape, then rotating and descending. For all its advanced capabilities, the Delta Clipper will encounter flight environments quite benign compared to those of existing spacecraft. Outbound flight accelera-

Figure 6



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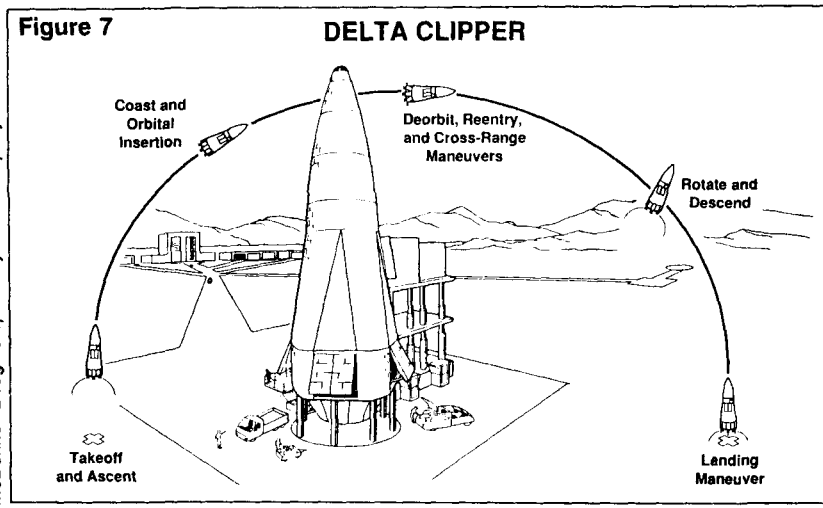
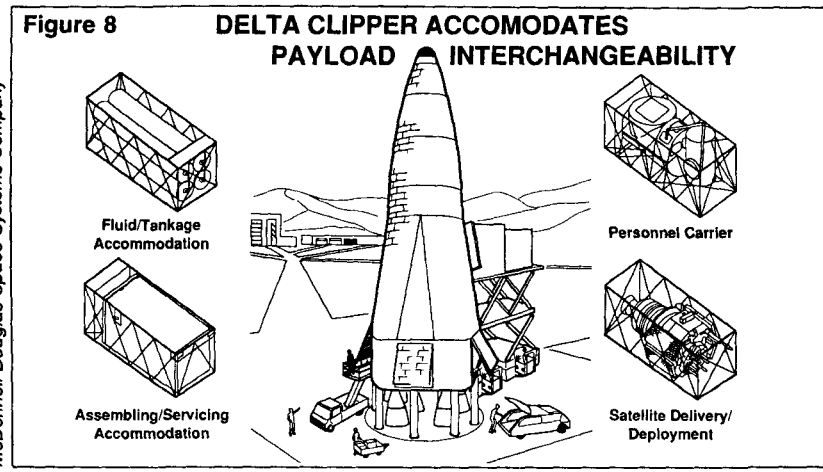


tion is limited to 3 g's, and the reentry acceleration loads are a little over 1 g.

Figure 8 shows the cargo handling capabilities of the Delta Clipper: with modular cargo space and modular cargo containers, haulage becomes routine, not at all like the customized payloads today's launch vehicles or shuttles must accommodate. In fact, the Clipper can fly with or without a crew module; its sophisticated onboard adaptive control system will not "know" the difference. By comparison, all U.S. crewed spacecraft to date have required a "human in the loop" to fly the machine back to Earth.



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* * *

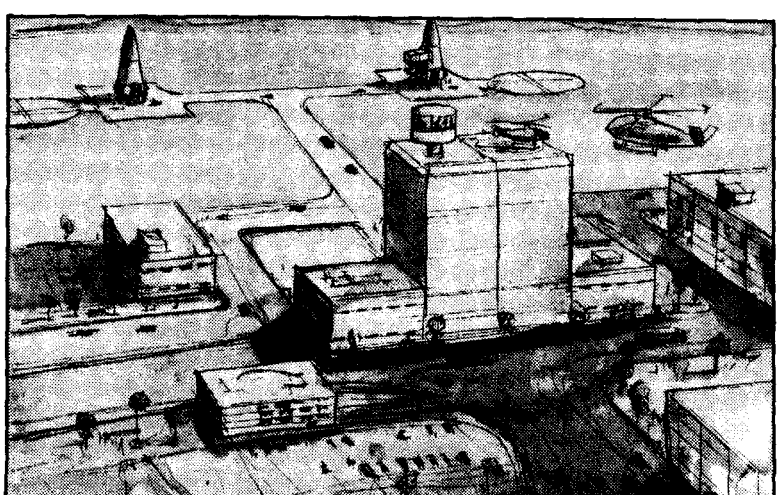
What Do We Do With A Delta Clipper?

Given cheap and reliable access to low-Earth orbit, the practical applications in space are literally limitless: much cheaper communications satellite launches and repair, supplying orbital factories and bases, space tourism. But with on-orbit refueling and some consumables upgrading, any craft capable of reentering the atmosphere and landing could make a much easier soft-landing in the airless, lower-gravity environment of the Moon. Thus, lunar exploration would be a natural extension of an effective SSTO. Even longer cometary and planetary missions could be mounted with additional stages and modules added in orbit.

As I proposed to one Congressional staffer who was fighting in committee for SSTO funding, a military version of the SSTO could take a contingent of soldiers and their equipment—helicopters, tanks and all—anywhere in the world in less than one hour flight time. All the landing pad it would need would be an airport, a parking lot, or a highway. As the U.S. cuts back on overseas bases, such a military capability might be necessary in a world of small, bickering nations, in which U.S. citizens or strategic interests might be threatened. And this capability may have other uses as well. Because the Clipper could land on any hard surface and be refueled by a few tanker trucks, it may be feasible to land anywhere around the United

Figure 9

ROUTINE OPERATIONS
MAKING THE SPECTACULAR MUNDANE



McDonnell Douglas Space Systems Company

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States, to "barnstorm" each congressional district. . . . (See Figure 9).

The Wall Street Connection

The Wall Street broker sat quietly the entire morning, listening in silence to one after another NASA official and government aerospace contractor explain how space would never be more accessible than it was now. How the 30-year-old technology of the current expendable launch vehicles would be sufficient for decades yet to come; how it would be at least 2005 before another crewed launch vehicle could replace the present shuttle program; how no SSTO could be flown until after that.

Finally it was his turn to speak. "Wall Street is investing billions in biotechnology," he explained, "even though there are no profitable products, because there is a vision for the future. Some may call it 'hype.'" He added that "space is a regulatory jungle," and that "the space launch infrastructure and the launchers are '50s and '60s vintage designs." Furthermore, "the cost of space is still prohibitive at $10,000 per pound."

Going on to praise the Delta Clipper as "the only thing I have heard today that gives me any hope for cheap and easy access to Space," he nevertheless warned that the project needs serious pursuit by the government, not merely "high profile demonstrations."

He concluded by saying, "Right now, there is nothing that we know is worth doing that has to be done in space. But give us that reasonable access and for certain the markets will develop themselves. Wall Street wants to be involved in new frontiers, but you have to make us buy into your vision. Wall Street will invest in things that are just good for the *soul*," he pleaded. "But you have to give us something to *believe* in!"

Television news programs will carry DC-X test launch live, commentators will describe the workings of the new craft, elected officials will speak of new frontiers soon to be accessible. If it is successful, investors and technophiles will dream; military around the world will pause to consider this new factor in their plans.

Assuming a good test, a few hundred people around the country will raise more than one toast to the first launch of a real rocket ship. Among the deserving celebrants will be, of course, the engineers and technicians who planned, designed, built, and operated the new craft. But in cramped quarters on Capitol Hill, in plush offices across the Potomac in suburban Virginia, and at homes of people on both coasts and in between, some of us will also toast the others—the visionaries and dreamers, the legislators and staffers—who have brought us this far, this close to the real Age of Space.

For not all progress is wrought through technology; policy makers—elected officials and advocates alike—struggled in their own way to make this first step happen. Some of these folks are science fiction writers; most of them are science fiction fans.

And every one of them, in their own way, has helped make history. ■

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Dr. Arlan Andrews, Sr., a frequent contributor to *Analog* for the last eleven years, recently completed a two-year tour of duty in Washington, D.C., where he served as a White House Fellow for the American Society of Mechanical Engineers (ASME) and as an ASME Technology Administration Fellow in the U.S. Department of Commerce. He is employed by a national laboratory in the Southwest.

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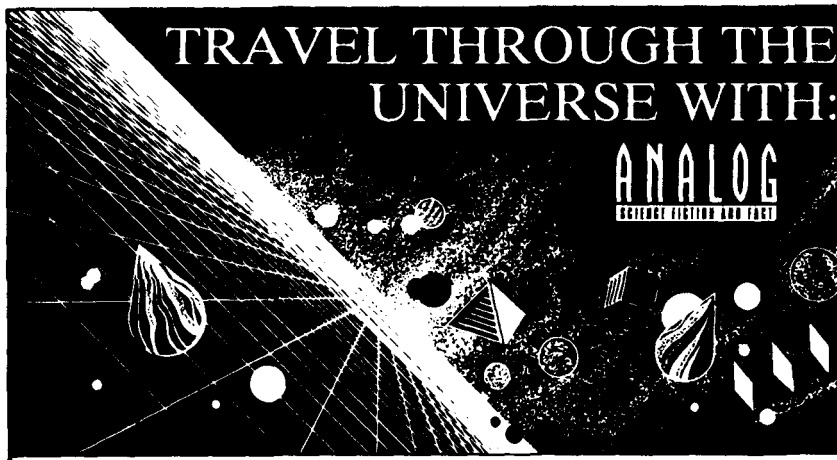

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Michael F. Flynn

GREAT, SWEET MOTHER

The really determined will go to great lengths to correct the most tragic errors. . . .

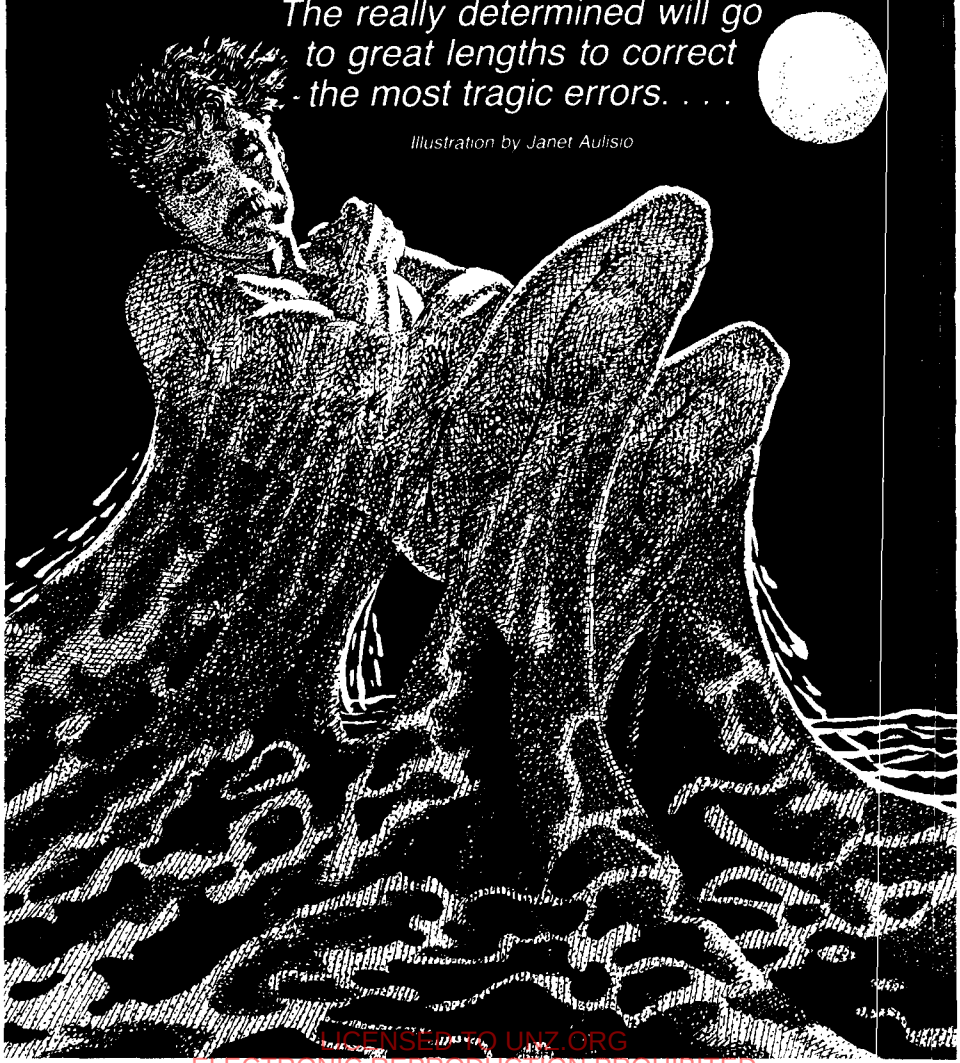

Illustration by Janet Aulisio

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I didn't really want to be disturbed, but as long as you're here, sit down. The sand is free; and it's cool and soft at night. You can listen to the breakers with me. There's food in the hamper, help yourself. No, not the steel one. That's cryogenic. You don't want to snack on what's in there. Yes, that's right. Those two. Hot dishes are in the red one and cold dishes in the blue.

No, really. Go ahead. I don't mind the company. It's one more experience to top off, and you're probably dying of curiosity.

" "

Sure, you are. You stopped, didn't you? Can't say I blame you. I must be a curious sight, sitting out here on the beach in the middle of the night, with baskets of food and a stack of books. I must be up to something odd, mustn't I?

Sit and listen. Close your eyes and still your breathing. Hold yourself as quiet as ever you can.

" "

Hear it? That soft, rushing sigh? Waves breaking on a midnight beach. The breakers whisper, don't they? A low, sibilant murmur, as if the world were slowly breathing in its sleep. Quite restful, really. And at night there are no gulls or shrieking children to drown it out. Just the ocean's slow susurration, the voice of a distant crowd. There are spirits in the sea, you know. What Andersen called "the people under the sea." I think that is why the wave tips glow at night.

Did you ever wonder what they were saying? The waves, I mean? Did you ever think that if you listened long enough and listened hard enough, the voices would come clear?

" "

Whose voices? Oh, I don't know. Davy Jones. The Little Mermaid. The crew of *Titanic* or the *Thresher*. Sandy. All those people under the sea. It's their chorus the waves whisper as they burst into spray. A thousand distant voices.

" "

Who is Sandy?

Oh.

Did I mention Sandy?

" "

Look at how black the sea grows toward the horizon! Black and cold and heavy. So dark you can't see the seam between sea and sky. Homer wrote about the "wine-dark sea," but he never saw the Atlantic. A stern ocean. There's nothing soft or gentle about it. Its islands are few and harsh and rocky. Iceland. The Hebrides. The Falklands. The very names conjure bleak, gray shores lashed with spray. There are no Tahitis out there.

Sandy is . . . a dream, perhaps. A memory. The reason why I am sitting here in the night on the cool, soft sand, listening to the hissing waves. Sandy is, or was, half my life. Soft curves and hard planes and a smile like a summer's dawn. Strong when strength was called for; gentle when gentle was right. Muscles smooth and supple. Sandy was a swimmer, did I tell you? Sandy loved the sea.

The sea loved Sandy.

" "

What am I talking about? Some-

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times I wonder myself. Do you have time?

Of course you do. Hiking along the sand at this time of night, you're in no great hurry to be anywhere. And it's probably just as well that someone knows what happened. Later, you can decide if you want to pass it along. There's no one I care to make my explanations to, anyway. Except Sandy; and Sandy will know soon enough. After that, I don't care who knows.

Hand me a sealed plate from the red hamper, would you? Number 127. It's baked chicken breasts à la Russe. Marinated in a paste of sour cream and paprika. And the wine from the blue hamper. Yes, the matching number. The right wine for the right meal. This one is a 1959, a good year for the Moselles, almost as good as '21, though well past its prime, now.

" "

What else do I have in there? Oh, a little bit of everything, I suppose. Beef, mutton, pork. Vegetables and fruit. Done every way imaginable. Sautéed. Baked. Broiled. Stir-fried. And wines, and juices and sherbets, of course. Everything except sushi. I hate sushi; and I hate sashimi. Ironic, when you stop to think about it.

" "

Oh, no. Just a taste of each; not a full meal. I'd never get through the list if I forced myself to eat a full meal of each. No, I just wanted to savor. I wanted the smells and the tastes.

" "

I have my reasons. And, yes, as a matter of fact, I did spend a long time planning this outing.

This cove . . . it was one of our favorites. The cliffs provide a bit of privacy, and they reflect the sound of the waves. A little crescent spit of sand. A "sandy strip," we called it when we went skinny-dipping here. There's a rock out there. You can't see it now, but if you close your eyes and listen, you can hear how the combers dash against it and split apart, and wrap around it like lovers after a quarrel. The shape of the sea gives an accent to the waves.

Where to begin. . . . It's all a seamless whole; so I'll just grab a thread and start unraveling.

Sandy had two great loves in life. Well, three, I suppose. One was the sea. Those boundless horizons and hidden depths. Waves that come crashing from across half the world, like the messengers of God.

The other was biology.

" "

Marine biology, of course. I'm surprised you asked.

That was how we met. Doing postdoc at Wood's Hole. I was into cetaceans: Sandy was into cephalopods.

Whales and octopi, friend. Whales and octopi. Those secret rulers of the sea.

It was mutual respect, at first. Professional regard. But respect deepened into admiration, and admiration blossomed into love. I've always felt pride in that. That we were friends before we were lovers.

It began with a few touches. Tentative, half-accidental; both of us ready to pull back. Afraid to admit to the trembling thrill those touches trig-

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gered. Then, finally, one long, tender night, a discussion of cladistics and gene sequences somehow turned into one of hopes and fears, and of aches and longings. I don't remember exactly when our lips first found each other.

Have you ever made love under the water? Have you ever floated in the calm, lazy world beneath the surface and locked your rhythms into the rhythm of the sea? Swathed in the moist, cool, lubricating sea, stroked by the currents and the kelp; the world cast a deep blue-green. Inside and outside and inside-out inside the abiding womb of the planet. What is love between a man and a woman but a desperate attempt to push back into that small, dark ocean where we floated before we were born? The sea is the great, sweet mother of us all. We were born there; tottered out of it like newborns on stiffened fins into a strange and arid realm. We still carry it with us, inside us. Our blood is a salt water soup in a bag of skin. It's the sea that's real. Only the sea.

" "

Yes, I suppose I do wax a little mystical at times. I've always bent that way. Archetypes and symbols and resonance. Whenever I read *Moby Dick*—

" "

Of course, I've read *Moby Dick*. I am a cetologist. It's in that stack of books there. No, the larger stack. Those are the ones I've finished rereading. *Moby Dick* and *Lord Jim* and *Twenty Thousand Leagues Under the Sea* and all of *Hornblower*, naturally. Cousteau. Odysseus wandering across the face of that wine-dark sea of his. But *Huckleberry Finn* is in there, too. And Kipling, and *Angels at the Ritz*, and *The Sign of Four*, *The Witches of Karres* and *Beggars in Spain*, *The Cowboy and the Cossack*. Every book that ever made me laugh or cry. Or while away an idle hour. Or think, long into the night.

" "

What's so funny? That I'm sitting on a deserted beach at night, nibbling at gourmet meals, and rereading every book I've ever loved? Can you think of anything more worthwhile?

" "

Well, yes. Love under the water. There is that.

Sandy and I joined the Human Genome project together. By that time, we were "an item." Neither of us could imagine life without the other. I still can't; even though Sandy is down there and I'm up here. I've thought about it a great deal, ever since Sandy went overboard. That was the night my heart cracked.

Damn.

Oh, damn . . .

I . . .

" "

I'm sorry. I can't help it. When I think about Sandy's face gazing up through the tossing waves—that look of utter surprise and utter longing. Then, only a pale underwater shape, sinking farther and farther, growing paler, finally vanishing.

We had kissed one last time. A passionate, longing kiss. A last, tender caress. Then, while Sandy stood at the rail gazing out at the swell, I pushed and . . . well . . .

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" "

No, we hadn't quarreled. Not exactly.

" "

Listen, I don't care if you understand or not. I was minding my own business and you butted in and I've got books to read and meals to taste and I haven't got that much time left. So why don't you keep on going wherever it was you were headed.

No. The hell with it. I don't need to explain anything to anyone.

" "

To myself? Why would I . . .? Oh, hell. All right. You might as well stick around and hear the rest of it.

Hand me Number 128, would you? It's a Kentucky Hot Brown. No, no wine. Beer with this one.

Thank you. You know, no one outside Kentucky has ever heard of this. . . . Just a bite, now. Mmm, yes. Sharp. It's best with a sharp cheese. I've used cheddar.

" "

Go ahead and laugh. But tell me. If there was something you loved, something you cherished; and it was something you knew you could never do again, ever . . . What would you do the night before?

Well I like good food and I like a good book. So . . .

" "

OK, you tell me. Why do you think I'll never taste good food or read a good book ever again? Why do you think I'm sitting out here on a midnight beach?

" "

Not even close.

Where was I?

Yes, the Genome Project. That was just after SingerLabs became prime contractor. Watson was long retired and most of the original flush of enthusiasm had passed, but Jessica Burton-Peeler revitalized things.

" "

Yes, the cure for Huntington's chorea. And the cure for sickle cell anemia two years later. Once the right part of the code was cracked, tyling the nanomachine to repair it was straightforward engineering. SingerLabs made a bundle, of course; but the marketing rights were part of the contract.

But Sandy and I didn't work on that end of the project. We played with the junk.

" "

Junk genes. Introns. Ninety-nine percent of the human genome doesn't code for anything.

" "

I know it sounds like a waste. All those nucleotides not doing anything; unread by the body. It's like reading a few meaningful sentences strung through a mish-mash of words, phrases, fragments and random letters. Like those acrostic puzzles where you're supposed to find the words in a grid of letters. You have to read in all directions. Up, down, left, right, diagonal. And the words in any particular sentence don't even have to be consecutive. A gene consists of a mosaic of nucleotides scattered here and there throughout the DNA strand. Somehow, the body reads it. Creates amino acids and all the rest. Don't you find that curious? Don't you find that remarkable? I do.

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Think of the way files are stored on computer disks. Files needn't be written to consecutive addresses. There are flags and pointers that let the operating system hopscotch from address to address. When you erase a file, you don't actually erase the information; you only remove the flags. As time goes on, and files are erased, added, expanded, your disk becomes a mish-mash of readable address mosaics—the currently saved files, and unreadable ghost bits—remnants of old saves and forgotten files.

" "

Yes, exactly. It does sound a lot like "junk genes." That's what we thought. Addresses correspond to locations on a DNA strand; genes, to files. The geometry is different, but the concept is the same.

Yet, why should file storage on a computer disk—which humans invented for human convenience from cumulative prior art—why *should* it behave like gene storage on a DNA strand?

I don't know. Maybe it's only a coincidence that we learned to store data and crack the genetic code at the same time. Maybe it's nothing more than enthusiasm imposing the paradigm of one field onto another. Or have we stumbled upon a fundamental truth of the Universe?

Our idea was to search through the junk for recognizable gene fragments. Old genes are eventually overwritten by evolution, as Mother Nature recruits unused nucleotides for new purposes. But fragments—perhaps even whole genes—might survive amidst the junk. "The shattered ruins of ancient genomes," I called them.

" "

No, it wasn't easy. But a journey of a thousand miles begins with a single stumble. . . .

I suppose it would have made more sense to look for apelike genes. We share 99 percent of our genetic information with the chimps, you know. But, we were marine biologists; we knew that territory. So, we looked for leftover gene fragments from the days when we lived under the sea. Genes we shared with whales and octopi and the like. Especially the whales; because they lived on the land for a while; then they went home, to their great, sweet mother.

We didn't have much hope of finding anything, really. It was purely blue sky. The sort of wild speculation that Dr. Peeler encourages. After hundreds of millions of years of evolutionary overwrites, we'd be lucky if there was anything left of those ancient, marine genomes other than a few useless fragments, impossible to reconstruct. Impossible even to recognize.

Talk about your luck.

We did find a few recognizable gene fragments. Sandy recognized them. They coded for certain details of fin development and gill structure. Similar to, but not quite like, analogous genes in familiar marine species. You see, different species don't always use the same nucleotides at the same addresses to achieve the same results. Mother nature is an opportunist. She uses whatever materials are available. So, in one species a nucleotide is recruited into one gene; in

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another species, into a different gene. Think how many different ways you could paraphrase the assembly instructions for a bicycle. Imagine trying to do it using only the words you have left over from other, discontinued instruction manuals. Different words; same results.

What made Sandy's discovery so exciting was two things. First, it gave us a hint of the kind of creature we once were.

" "

No, not fishes. We were never fishes. Today's fish have as many years of evolution under their belts as we do. But, Once Upon a Time, we were something very much like fish. Something that doesn't exist anymore; something that may never have left a fossil for us to find. Something we have no name for.

Don't you feel it? Don't you feel the slightest shiver? This wasn't a glimpse of dead bones—of the petrified casts of dead bones—but a glimpse of an ancient, living world. Like finding the scrap of an old, old photograph in the bottom of your trunk.

" "

The second reason?

I hate whalers. I hate them with a passion. I work with whales. I know them, and I love them. Those giant, gentle, humming beasts with their sad smiles. Singing through the oceans; nursing their children; dancing and playing in our bays and inlets. They shoot them with giant, explosive arrows. Arrows with barbs, so the more you pull against them, the more they dig into your body. Then, after you've exhausted yourself in hopeless escape, they shred you into strips for rich Japanese businessmen to nibble on, and boil down your fat for lotions, and—

Like I said, I hate them. Let them eat cow. A cow's destiny is to lie between two buns. It's what they were born for. A whale's destiny is to swim free and plumb the ocean depths. So—

" "

What have whales to do with our discovery?

Did you ever wonder why babies are sometimes born with webbed fingers and toes?

Sometimes, the body runs one of those old, old programs.

Carry the computer analogy a step further. What if we could restore the markers to those fossil genes? Could we reactivate them, perhaps? The body sometimes does it by accident, by misreading a flag. Couldn't we do it on purpose? I guess in the backs of our minds was the notion of doing the genetic equivalent of a "hard drive recover." If only enough of the older genomes have survived overwriting. . . . If only we could tyle a nanomachine. . . . Think about it. Doesn't it excite you? No species need ever be "endangered" again.

" "

How? Reassemble the lost genome from the fragments surviving in "cousin" species. Our very own introns may contain most of the working blueprints for Neanderthalers.

And the whales . . .

Whales are mammals, like us. Our common ancestor is more recent than those ancient, maritime genes Sandy and I found, so similar frag-

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ments are almost surely buried in the whale genome, too. If we could infect the whales with the right nannies, they could grow gills. They would never need to surface, never need to blow. They could stay in the ocean depths, safe from the harpoons.

" "

No, they wouldn't be whales anymore. But they would *be*.

It could work. A genius could make it work. A genius could see how scattered nucleotides locked together, like a Chinese puzzle. A genius could perceive which nucleotides in the ghost gene were missing. Envision the whole from the fragment in hand. Ninety-nine percent of the genome is junk, so there's plenty of material on hand that the body doesn't need, material that could be recruited to flesh out the missing parts. A genius could set the flags to restore continuity so the body's operating system could read the fragments as a single gene.

I'm a genius, did I tell you? I'm a genius. So was Sandy. Genius times genius is genius squared.

Sometimes, I wish we hadn't been. Sometimes, I wish we had been as dull as ditch water. Other times . . . other times . . . I don't know. Sandy and I both loved the sea. Loved the waves and the whales and the coral and the kelp. So maybe there was a rightness to what happened. A wyrd.

Even a genius can grow careless. Even Neptune nods.

We were trying to tailor water-rabbits. To discover if we could reactivate the ancient genes in another mammal. Gill-bunnies, we called them—

" "

No, it's not horrible. We were trying to save the whales, remember? And if, in the process, a few bunny rabbits learned how to breathe underwater, it was no harm to them.

We've been bio-engineering species for millennia. Do you think that sheep are natural? Do you think the Holstein cow existed in nature? How many different dogs have we created? Evolution gave maize three or four puny seeds; the Olmecs gave it row after row of great, juicy, golden kernels.

We did it the old-fashioned way, by patient breeding and hybridization, and it took generations; but we did it. We did it.

We do things much faster now.

It was an accident. The syringe was wrong way around in the tray, and Sandy reached without looking and was pricked on the hand.

At first, we thought that everything was OK; that not enough nannies had been injected to set up a self-sustaining population.

But, Sancta Maria, I do good work.

We took blood samples every day; and every day, they showed the nanny population growing, building strength, splicing new instructions into the cell nuclei. Then, as old cells died and new cells grew, they grew . . . differently.

I tried tyling new nanomachines; ones that could counteract the one at work in Sandy's body. But there was not enough time. Not enough time.

Sandy spent more and more time here, by the breast of the sea. Sitting

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in the sand, facing out toward the deep; back turned against the land, listening to the waves. There was a longing growing inside, something that Swinburne had sensed when he wrote:

I will go back to the great, sweet mother,

Mother and lover of men, the sea.

Symptoms began to appear. Webbing between fingers and toes. Gill slits appeared and deepened on the lower chest. Sandy began to have trouble breathing—the instincts were all wrong. I filled the bathtub with water so Sandy could sit in it, keep the gills wet, and still work.

It was nearly fatal. Fluoridation in the water. . . .

We both knew how it would end. Dear Lord, when I think how calmly Sandy took it all. Maybe the lure was overpowering even then. Sandy had always loved the sea. One day, the song of the Lorelei became too strong. We rented a sail boat, and skimmed out beyond the gulls and the breakers to where the sea gently rocked us and the swells danced in the Sun.

At the very end, Sandy hesitated, clung to me. Eros can sing as loud as Lorelei. So I had to push.

The gills worked fine. It's all a matter of learning new reflexes, of not breathing through the nose or mouth. Sandy surfaced after a while, treading water effortlessly, gazing at me with longing eyes. Then . . . then, the ocean won. I stood at the railing for an hour afterward, gazing into the depths. Then, when it was growing dark and the wind began to turn, I tacked back to shore.

Have you ever lost your lover to another? To a great, good friend that you've known all your life? For a long time, I didn't know whether I hated the sea or not. I wonder what it's like down there in the octopus' garden, down in Fiddler's Green. Sandy has to contend with barracudas and sharks. Drift nets. God, I hope the dolphins help. Dolphins have always helped. They say they were once the mermen and mermaids of legend; that they used to be part-human back in the Age of Magic.

" "

Still alive? Yes, I think so. There have been reports. Sightings. Some cod fishers out of Reykjavik dragging their nets off the cold coast of Greenland. An oil tanker west of the Azores. A cruise ship nearing Aruba. Wild reports. No one believes them. No one credits them but me. Maybe you can tell them after I've gone.

" "

Yes, of course, I'm going, too. Did you think I was sitting here mourning my loss? Did you think I was going to kill myself? No, not while Sandy and I can still be together, under the waves. What do you suppose is in that cryogenic cooler? What do you think these welts are on my abdomen?

No, go ahead and look. By tomorrow morning, when the Sun crests the waves, they'll be full-fledged gills.

" "

Yes, it is a big ocean. But we'll find each other. I'll have a whale sing across the sea. I'll sweep the Gulf Stream from Carib to the Isles. And

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someday . . . someday. . . .

Sandy knows I'll come. We'll ride the currents together and dance among the seaweed and kelp. We'll make love under the waves until age or shark does for us.

I'll miss the books, though. Paper wouldn't last a minute down there. And the food. . . . You can't cook in Fiddler's Green, and there's no subtlety of taste or smell, not for humans—everything will smack of brine. Not much conversation, unless we broach and fill our shriveled lungs with air again. Nor even much sound—just squeaks and whistles and clicks, and the distant, mournful songs of the humpbacks.

Hand me number 129, would you? I want to remember the tastes. I want to remember the smells. From now on, it will be raw fish we snatch for ourselves from passing schools.

And, dear God, I do hate sushi. ■

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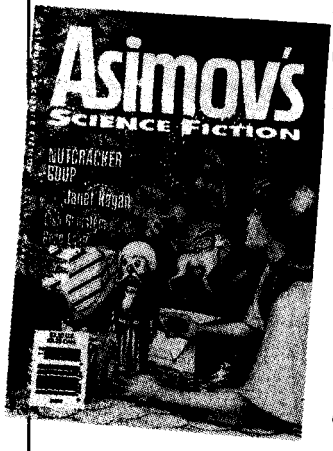

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THE ALTERNATE VIEW John G. Cramer

DUMAND: NEUTRINOS FROM BENEATH THE OCEAN

Neutrinos are perhaps the most elusive and mysterious of known fundamental particles. They steal energy from nuclear beta decay, from the Sun, from nuclear reactors, from distant supernovas. An average neutrino from a beta decay could travel through solid lead a light-year thick without interacting. Neutrinos are prime suspects for "dark matter," the mysterious substance that is responsible for most of the mass in our Universe. And, as previously reported in this column (*Analog* 9/92), there is a growing body of evidence that electron neutrinos may be "tachyons," particles that *always* travel faster than the velocity of light and that slow down when given more kinetic energy. But that is another story.

In this AV column we will have a look at the DUMAND project, a new $10 million detector partly funded by the U.S. Department of Energy for the detection of ultra-high energy neutrinos. DUMAND stands for *D*eep *U*nderwater *M*uon *A*nd *N*eutrino *D*etector. It is now under construction in Hawaii and will come into operation in 1993-94. It is to be placed almost 3 miles deep on a level stretch of Pacific Ocean bottom about 18 miles west of Keahole Point on the Island of Hawaii. Floats anchored to the ocean bottom about 40 meters apart, and arranged in an octagon around a central junction point, will support long vertical strings of sensitive light detectors. DUMAND will be connected to its land-based laboratory by bundles of fiber optics cables. AT&T will lay the cables to shore, and the U.S. Navy's manned deep submersible DSV Sea Cliff will be used to connect, service, and repair the parts of the detector.

But before getting into the details of construction, let's focus on the primary question: "What is DUMAND for?" Briefly, it's for the creation of a new science of high-energy neutrino astronomy, for looking where no one has looked before, for finding the spots in the sky where the most energetic processes in the Universe are taking place.

Our Universe contains a small

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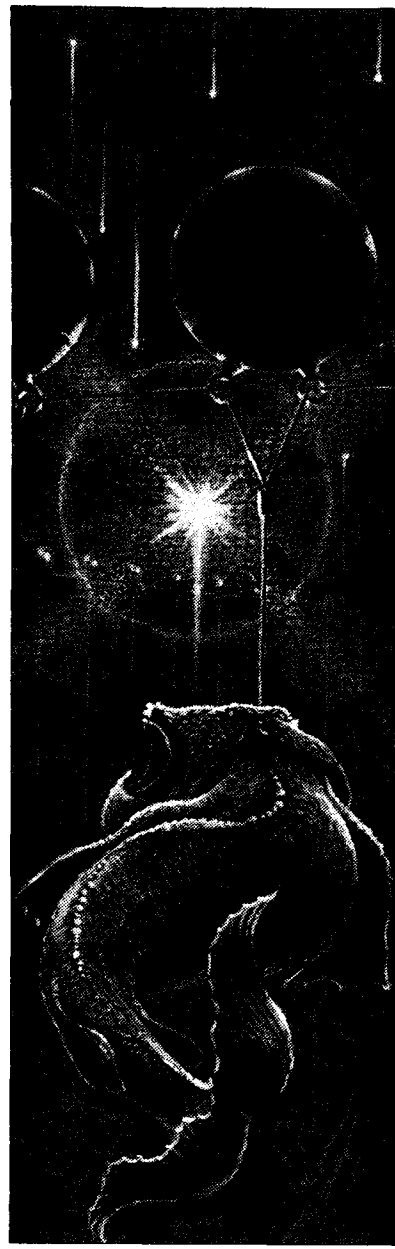
number of very special "objects" that deliver to our upper atmosphere a "rain" of very high energy particles: protons, heavier nuclei, electrons, photons, and neutrinos. These high energy particles from space are called cosmic rays. The details of the processes that produce cosmic rays are not well understood, but we are coming to realize that these very high energies are ultimately the result of the direct conversion of mass to energy near the event horizons of black holes.

We would like to map the sky for the sources of cosmic rays, to learn where they come from and what they are. Of the cosmic ray particles listed above, only the electrically neutral photons and neutrinos are useful for "back-tracking" to their sources. The other particles, protons, nuclei, and electrons, have electrical charges that cause them to be deflected in random ways as they pass through the magnetic fields of the Galaxy, the Solar System, and the Earth. This scrambles their incoming direction so that it cannot be related to the direction of the source. To locate the cosmic hot spots, therefore, photons or neutrinos must be used.

Photons, of course, are the mainstay of conventional astronomy. Photons in the microwave, infrared, visible, ultraviolet, and x-ray regions of the electromagnetic spectrum have been used by astronomers to map the Universe. There have also been studies of the sky with gamma rays, photons with energies of about 0.5 MeV or higher. But as the photon energy



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rises, detection becomes more difficult and direction information more elusive. Gamma rays interact too much with Earth's atmosphere, so all studies of cosmic gamma rays must be done in space or using high altitude balloons. The sizes for gamma ray detectors also depend on the gamma ray energy, with very high energy gamma rays requiring extremely large detectors. These constraints have, up to now, severely limited gamma ray astronomy.

But if detecting gamma rays from space is difficult, detecting neutrinos is even more difficult because the interaction with matter of neutrinos is about 10^7 times weaker than the interactions of gamma rays. If gamma rays interact too much with the atmosphere, neutrinos interact far too little. Typically neutrino detectors must be placed deep underground, where neutrinos can easily reach the detector but other particles are blocked by the shielding of the Earth itself. Neutrinos have only been directly detected in a few experiments, all of which have required large quantities of matter and elaborate detection schemes. For example, the underground solar neutrino detector located deep underground in the Homestake gold mine, where 15-18 MeV neutrinos from the Sun were first detected, used about 380 tons of per-chloro-ethylene cleaning fluid as its detection medium. (See my columns about solar neutrino detection in the 5/86 and 9/92 issues of *Analog*).

The DUMAND detector is designed to detect cosmic ray mu-neutrinos with energies in excess of 1 TeV (10^{12} electron-volts of energy) as they pass through sea water. Although a neutrino has zero rest mass (or perhaps nearly zero), a 1 TeV neutrino has a mass due to its energy that is greater than the mass of 1,000 hydrogen atoms. When such a mu-neutrino (electric charge = 0) has a hard collision with a down quark (charge = $-1/3$) in a nucleus there is some probability that the neutrino and quark will exchange a W boson, with the result that the electric charge of the neutrino drops by one unit while the charge of the quark increases by one unit. The mu-neutrino thus becomes a muon (a mu lepton with electric charge = -1) and the down quark becomes an up quark (charge = $+2/3$). The newly created muon keeps essentially all of the energy of its parent neutrino, but it is now electrically charged. It will have a gamma factor (or mass-increase factor) of about 10,000 and a velocity only 6 parts in 10^9 less than the velocity of light in vacuum. But in sea water visible light travels only about $3/4$ of its speed in vacuum. Therefore, the 1 TeV muon, newly made from the cosmic ray neutrino, will be traveling about 33% faster than the speed of visible light in water.

When an airplane exceeds the speed of sound in air (breaks the sound barrier), it makes a shock wave that is popularly known as a "sonic boom." Similarly, when an electrically charged particle exceeds the speed of light in transparent medium like water, it makes an electromag-

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netic shock wave. This shock wave is called Cêrenkov radiation, a wave front of blue light that spreads out in a cone from the track of the superluminal charged particle. The cone of Cêrenkov light has a characteristic direction that can be analyzed to determine the direction of the incoming muon (and hence the incoming mu-neutrino) to a directional accuracy of about 1%.

In a conventional high energy physics experiment, a Cêrenkov detector might be made from a slab of transparent plastic optically coupled to a photomultiplier tube. In DUMAND the plastic slab is replaced by 2,000,000 tons of sea water optically coupled to 216 hemispherical 15″ diameter photomultiplier tubes, each housed in a 16″ spherical pressure vessel that can sustain the water pressure of 100 atmospheres present in the ocean depths where the detector is located.

About half of DUMAND's funding, approximately $4.8 million, comes from the U.S. Department of Energy, the other half in the form of photomultiplier tubes (PMTs) and fast electronics, key components of the detector, will be the contributions of Japanese and European collaborators. About half of the PMTs will be made by the Hamamatsu Corporation of Japan and will be conventional "venetian blind" photomultipliers custom made for DUMAND to achieve the required specifications of sensitivity and timing. The European half of the PMTs will be made by the Phillips Corporation. The Phillips PMT uses an innovative two component design, a large image intensifier coupled to a small 2″ photomultiplier. Each of the PMT types has some advantages, and a mix of the two types in the detector brings positive benefits.

A light-sensitive detector like DUMAND must be placed in a dark environment, because ambient light is a source of background. Fortunately, essentially no daylight can penetrate the ocean to a depth of three miles, where the DUMAND array is located, and the principal light sources will be from bioluminescence and from Cêrenkov light from ^{40}K radioactive decays in the sea water. Neither of these is a problem, as demonstrated in November, 1987, when a small DUMAND prototype string of PMTs and associated hardware was tested in the ocean near Hawaii at depths down to four km.

One significant problem of DUMAND is the position calibration of the detector strings, which hang above the ocean bottom on float-supported cables. Currents in the ocean depths can cause significant movement of the cables that could, if not taken into account, lead to significant errors in interpreting the Cêrenkov light from energetic muons. The DUMAND experimenters solve this problem by surrounding the detector with sonar broadcasters producing chirping pulses of sound that are picked up by microphones placed along the detector strings. This locates each microphone on each string to an accuracy of a few centimeters and eliminates potential errors from the motion of the strings.

Another source of background in

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DUMAND comes from muons produced in the upper atmosphere by cosmic ray protons, nuclei, electrons, and gamma rays. Some of these muons have enormous energies and can, with some probability, penetrate the ocean even to a depth of three miles. These high energy particles may be interesting in their own right, but they are not predominantly produced by neutrinos, the particles of primary interest. Fortunately, there is an excellent way of distinguishing neutrino-generated muons from other cosmic-ray generated muons. If the muons are observed to pass upwards or sideways through the detector, they can only come from neutrinos that have passed through the bulk of the Earth as neutral particles, before being converted to a muon in a collision with a quark. A muon traveling on the same path would have been absorbed by the Earth. The muons from the upper atmosphere, on the other hand, must travel downward through the detector. All upward going muons must be the product of neutrino events.

What cosmic cataclysms can produce neutrinos with such enormous energies? There is some speculation in the astrophysics community. Recent calculations have predicted that active galactic nuclei, the power source for quasars and other high energy phenomena, can produce enough primary neutrinos to make thousands of ultra-high energy neutrino events per year in the DUMAND detector. Even using more conservative estimates of the cosmic neutrino flux, the DUMAND collaboration expects about 80 neutrino events per year at energies above 10 TeV, and 300 events per year at energies above 100 GeV, which is about the threshold of sensitivity for the detector.

DUMAND is a delightful scientific adventure, an initiative that will show us a new aspect of nature, a technological foray that combines the forefront techniques of electro-optics, microelectronics, communications, high energy physics, and oceanography. And, from the point of view of the experimenters, the shores of Hawaii will be a wonderful spot from which to explore the mysteries of the universe.

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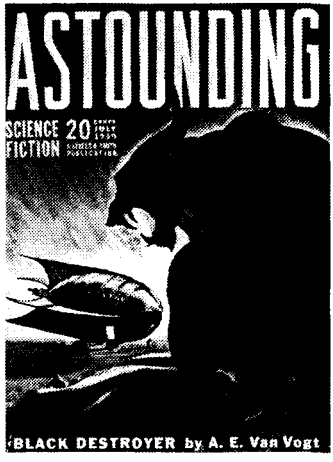

Critics mark this issue as the first "great" issue edited by John W. Campbell, Jr. It contains the first published story, "Black Destroyer," by A.E. van Vogt and the first story by Isaac Asimov to be published in **ASTOUNDING.**

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Gregory Bennett

TINKER'S SPECTACLES

When is strength a weakness—or vice versa?

Illustration by Vincent Di Fate

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Life was tough enough for a second-generation crafter in a pioneer town without having to endure the smell of the aborigines. The day started hot and dusty, but when the wind shifted to the south the vile aroma of the swamp was inescapable. I couldn't pay the power bill, so the electricity had been off for three days. Some joy-riding kid had crashed his hopper into the wall of my shop, and I couldn't afford the glass and resin to fix it; I had to make do with a patch made from an old table top held in place with duct tape. Swamp gas leaked through my patch like it wasn't there.

I'd called Wandalee after lunch. She didn't have any money either, so we couldn't go to the pictures. Her folks didn't want her to waste her time with an impoverished crafter when all those wealthy ranchers were around, so I couldn't go to their house. And she didn't want to come to my place when the the air conditioning was out and the swamp was high. The best I had to look forward to was a lonely night rereading an old novel by candlelight.

The beans I'd had for lunch had turned against me with a vengeance.

Then a Pled waddled into my shop, adding its own pungent pheromones to the aroma from the swamp. This was during the rut, mind you. By some polite agreement reached before I was born, the Pled never came into town during their mating season. Men thought their odor was downright disgusting. Women said they found it to be pleasant, but most unsettling. I'm a man. Trust me; the smell of a Pled during the rut is disgusting. I can't imagine why Pled sweat—it's not really sweat, you know—brings such a high price on the black market.

Despite an edict from the colony manager to be polite to the aborigines, I was ready to chase the abo out. I started to yell at the Pled to wipe the mud off its grimy feet and to keep his claws retracted so they wouldn't carve up the floorboards. But before I could finish my diatribe, it spoke.

That normally wouldn't have put me off, but what came out of my translator was, "Crafter Harsifal Ambrose, a set of spectacles for purchase by this Pled can your human oneness manufacture?"

A paying customer! I quickly slapped the CANCEL button on my translator, giving myself a shot in the solar plexus in the process. Fortunately, I caught the translator before the machine could decide I had finished my sentence and begin to generate the subsonic howls the Pled used for speech. Suddenly the manager's edict sounded pretty good to me! Not only was this fellow—the Pled really was a fellow; as I said, it was their mating season so he was in full display, his wands waving around behind him like the tines of an enormous three-pronged fork—not only was he a paying customer; he was also a *Pled!*

No Pled had ever shown any interest in buying anything from an Earthman. Nearly everybody had tried at one time or another to separate a Pled from his gemstones, and back then they all had gemstones. But the

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aborigines just didn't have any interest in anything we had to trade.

My opinion of the lens-crafting trade did an abrupt about-face. If the Pled needed glasses, there might be some hope for my business after all!

"What's your name?" I asked the Pled, trying to make pleasant conversation as I climbed up on my stool so I could examine his eyes.

He rumbled something, and the translator said, "I am sung as Tinker. My plates are smoothed by acquaintance of your oneness, Harsifal Ambrose."

By stacking a small crate on top of the stool, I managed to get on eye level with him. "Pleased to meet you, too, Tinker," I said. "Now, what seems to be the problem with your eyes?"

"Sees brightly wise eye of Tinker. Wisdom great as wortle tree has wise eye of Tinker. Sees quickly, with cleverness exceeding the lampsnake, clever eye of Tinker. Drop it in sucking mud; follows naught beyond my wands noble eye of Tinker!" the translator said in response to the alien's low thunder. His breath was almost as bad as his body odor.

"Uh, which is your noble eye?" I asked, assuming the reference to sucking mud was the Pled's idea of an expletive.

"Here," the Pled replied, one enormous claw indicating his enigmatic third eye, the one at the top of the triangle, beneath his upper brow.

I looked him in his third eye; the eye looked back, clear and bright as any eye I've seen. His brow wrinkled into a semicircle above the eye, forming what I assumed to be a hopeful expression.

There's no way his head would fit into my optidoc, so I had to do an eye examination the old-fashioned way. The retina looked good, assuming a Pled retina is supposed to look like a human retina. He didn't even flinch at the puff of air I used to test for glaucoma, though I discovered the Pled have a transparent nictating membrane for each of their three eyes. I couldn't find any obscurity in the membrane. The pressure reading didn't mean a thing to me until I tested his two other eyes and found them to be the same. The pressure of aqueous humor in a Pled's eyes is considerably lower than a human's.

With a pair of scissors, a piece of heavy cardboard, and some raucous swampdock language, I fashioned a mask he could hold over two eyes at a time. I climbed down off the stool and stood a few paces in front of him, clearly in his field of vision and farther away from his body odor.

"Do you know the English alphabet?" I asked.

"New wonder is human symboling knowledge for drinking by this Pled," Tinker replied.

"I take it that means no," I muttered.

The Pled thought about this for a moment, rumbled something, and the translator came out with, "No. Knows no human alphabet this Pled."

"Well, this character is a B," I informed him, pointing to the largest B on my eye chart. "Can you see it clearly?"

"Shines brightly B upon mind of

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Tinker," the Pled answered. "Rejoices within this Pled to sing symbol of Crafter Harsifal Ambrose as B." With that, he shuddered and rubbed his tail against his wands a few times. This unnerved me a bit. At any other time, that tail-rubbing business was an expression of great happiness, but during the rut, it could mean *anything!*

"Very good," I answered, trying to maintain my aplomb. I could hear the letter B quite clearly among the grunts and rumbles of his language.

The Pled bent into a posture that lowered his eyes below mine (no small feat for a brute his size) and tilted his enormous scaly head to one side. I was surprised at the expression of humility.

"Forbearance of Crafter Harsifal Ambrose for singing brothers of B prays this Pled," is what the translator claimed Tinker said.

The customer is always right. So I indulged him. "This is an F, and this is an X, and here is a Q. Notice that the Q has a tail, but this O does not—"

I stopped, awed by Tinker's excitement. He was dancing back and forth from one gigantic foot to the other, his tail beating a rhythm on his wands, and humming at frequencies below sixty hertz. All three eyes were locked on my eye chart.

"Are you all right?" I gasped.

"Offending of Crafter Harsifal Ambrose this Pled. Wanes Tinker," he replied and started backing quickly toward the door with his head even lower.

"No! Wait!" I shouted, but canceled the translation before it got out. I tried to think quickly and came up with, "Tinker is most pleasing to Crafter Harsifal Ambrose. But you may call me Harsifal."

As soon as my translator finished growling at him, the Pled caught up short, his claws leaving fresh ruts in my floor. After a couple of hops that shook the whole building, he started slapping his wands again.

"Waxes Tinker for song of Harsifal," he said.

That's the way it went. One letter would have been sufficient for the eye exam, but within ten minutes I taught him the whole English alphabet and all the numerals. Tinker seemed to grow more excited with each one. Up close, he could read all the lines on the eye chart, even those little letters at the bottom I can see only with the lower lenses of my bifocals.

The real surprise came when I started backing away, asking him to read the chart from a distance. A line of letters near the middle of the chart was supposed to be legible to normal human eyesight at twenty feet. (That's optical tech talk for about six meters.) But, when I was twice that far from Tinker with my back against the wall, he could stand in the door and read even the smallest print on the chart! I switched charts, to make sure he hadn't just memorized the order of the letters, and confirmed the phenomenon.

The next phase of testing, where we blocked off one eye and then two, told the story. Tinker's lower eyes were just about human normal. His long-distance vision came from his

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larger upper eye—his "noble" eye. So much for his assertion that his third eye followed naught beyond his wands.

We experimented with some color plates. The chromatic acuity of his lower pair of eyes was much better than mine, but he was almost color-blind in his noble eye. I thought I had found the problem with Tinker's eyesight—unhappily so because there wasn't much I could do about color-blindness—but Tinker assured me most poetically that the color vision of all three eyes was normal for a Pled.

I led Tinker out the back door, down to the little dock at the end of the alley. We had to go outdoors to continue these tests, but there was no way I was going to be seen walking about in town with a male Pled during the rut! At the dock, I eyed my little john boat skeptically, comparing its volume to Tinker's massive bulk. I hoped our combined weight wouldn't sink it.

For the first time, I noticed he wasn't wearing the jeweled harness I'd seen on most other male Pled. His sole garment was a wide leather belt, but the pouch hanging from his belt could easily have contained a fortune in gemstones. That observation renewed my hopes to help him lighten the burden of his pouch.

Tinker seemed to be excited by the prospect of a boat ride; he was going at his wands again. I half expected him to jump into the boat after me, sending us both to the bottom of the swamp. To my relief, he stepped carefully from the dock. Water came up too close to the gunnels for my comfort, but Tinker didn't seem to be the least bit nervous. With me gingerly poling and him cooling his tail in the water, we made our way among the cypress knees to the park.

It was cooler at the park, almost pleasant since my respirator filtered out most of the swamp's, and Tinker's, aroma. Besides, once out in the open, I could stay upwind of him.

Just to make sure we wouldn't be observed, I lead Tinker all the way across the park and out the gate. I didn't have much protective gear with me, but I wasn't too worried about going outside the screen.

Every native Vandalian life form goes into heat at the same time, plants and animals both. That includes gyrbirds as well as Pled, so I didn't expect to run into any gyrbirds. Those monsters should all have been off in the mountains, making baby gyrbirds so there would be that many more of the pests next year. We'd cleaned out nearly all the other fearsome thingies that Vandalia had to offer, encouraging them to find other living quarters at least ten kilometers outside the screen. Oh, you'd still run into the occasional lampsnake, especially back then; but the flashing light that Vandalian creatures find to be so tantalizing is just a warning beacon for us Earth types.

The only other thing to worry about at that time of year was the slimy airborne goo some of the plants use for pollen, and my respirator took care of that.

Out past the park, we had plenty of open space to put Tinker's vision to

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the test. I used my binocs to measure the distance to several wortle trees and had Tinker hop to each one. He stopped to read the eye charts as he went. Finally, at about six hundred feet, his distance vision started to fail him; he could no longer read the smallest letters on the chart. Unfortunately, this was no surprise to Tinker. For all Pled the song of the noble eye fades into harmonies, as he put it, at that distance.

It was frustrating. I had a paying customer standing right in front of me—maybe even just the first representative of a whole new class of paying customers—and I couldn't even figure out why he needed glasses! My lens-crafting business was doomed.

I found a reasonably dry patch of thatch and plunked myself down to think about it. Tinker must have understood my gesture, because he followed suit, crunching a gorse bush into oblivion when he sat down. His naturally slump-shouldered posture slumped a bit more than usual. I remained silent, contemplating his three eyes.

He was examining the thatch around him. Suddenly the Pled let out a snort that sounded like something heavy falling into the swamp a mile away. Faster than I could follow, one clawed hand swiped at the ground and emerged with a clump of barton roots. Not quite looking in my direction, he held the clump out so that I could select one of the little tubers. They looked clean enough, still dripping wet from the fresh water found just below the surface, so I broke a barton from the clump and started munching it. When Tinker did likewise he revealed a set of huge molars to back up his formidable incisors.

I figured this must be a Pled thing, some sort of male-bonding ritual that involved sharing food during a quiet moment. I enjoy the sweet carroty crunch of barton roots. There's something about them—a bowl of bartons in ice water and a mug of coffee have always seemed to be the perfect accompaniment to a good novel. Maybe they contain some kind of drug that puts the mind in the mood for that sort of thing.

Lens crafting wasn't always that bad. But sixty-five years ago some bright boy on Earth had come up with a drug that would cure myopia in less than four months. Naturally, we heard it about three years ago when the message finally got here to Vandalia. I was a little apprehensive when I first heard about it, but not much. After all, we were always getting messages about some cute thing invented on Earth six decades before.

Besides, this drug was a doozie—it was transgenic. The only way it could be manufactured was to fiddle with a mammal's DNA so the drug would be produced in her offspring's milk. The last time the Terries came up with one of those it took the ranchers six years to get a goat that could produce gobbledygookinase, some kind of heart drug. I figured I could sell a lot of glasses before this myopia thing was a threat to my business.

That wasn't the real kicker, though. This eyeball-shaper drug was linked to the recipient's DNA. For humans,

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it could only be produced in human milk! And since the stuff had to be kept at normal body temperature and couldn't be exposed to air, the most effective way to administer it was direct from the manufacturer to the patient!

Harsifal, I told myself, you have nothing to worry about.

I should have worried.

But how was I to know that in less than a year one of our geneticists would come up with a way to modify milk glands directly, so folks didn't need to wait until the next generation to produce the drug? I should have realized they'd be able to find lots of lactating women on Vandalia. It's a new colony, after all; motherhood is as common as athlete's foot around here. This place isn't like Earth. You don't need a license, just a positive attitude and some music with a good beat to it.

When that jerk over at the pedialab found out the stuff was good for babies, that clinched it. Every mom on the planet showed up to have her jugs fixed so her little darlings would have perfect eyesight and good arteries. By the next Landing Day, there were thousands of drug factories walking around. I don't know how many women decided to make a little money on the side by selling unlicensed pharmaceuticals, or what their husbands thought about it, but I do know my business in selling eyeglasses okefenokeed almost overnight.

I'd sold a lens two weeks ago, nothing since. And that was a one-of-a-kind deal. A kid down the mire wanted a corrector for a catadioptric telescope he'd built; as if he had a chance to see anything through the haze. There's not much of a market for astronomical instruments on Vandalia.

So the market for lenses didn't look too bright. I'd all but decided to give it up and hire out to a ranch when Tinker walked into my shop and told me he wanted a pair, or rather a trio, of specs. But I couldn't find anything wrong with his eyes! It was the most irksome thing to happen to me since Wandalee started visiting that rancher's kid.

"Swamp take it, Tinker!" I bellowed, breaking our silent reverie. "How in slime can I make glasses for you if there's nothing wrong with your eyes?" Fortunately, the translator was programmed to handle my language diplomatically. The Pled mistook my screaming for joyous singing.

Tinker rolled back on his tail and hopped to his feet, happily buzzing and booming. My translator insisted this cacophony meant, "Plates of Tinker rejoice with yours, Harsifal. Arrives epoch of demonstrating glissando of noble eye of Pled which sooner than Harsifal touches star of Vandalia?"

All I could reply was, "Huh?" But my translator gave Tinker a refrain that sounded like Beethoven's Fifth played on timpani, with tuba accompaniment.

The Pled rolled his head to one side and stared past me, holding the pause long enough for me to become

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uncomfortable. Finally, he grumbled a short response.

"Is time now for testing noble eye of Tinker in its watchfulness?" my translator asked.

Watchfulness? What had I overlooked? It was heartening to think that there was more to test, but what? From all I could tell, his vision was well beyond what humans would call perfect. There must be something, though, or Tinker never would have violated social and tribal canons by coming to see me during the rut. Briefly I considered consulting with friends at Vandalia Xenobiological Institute, to see if they could understand him any better than I. But that would have meant marching right down Main Street with a Pled at my side. I shelved the notion, to be used as a last resort, and tried a different tack.

"Tinker, why do you have a third eye?" I asked. The three-eyed creatures on Vandalia never had made any sense to me. The Pled weren't the only ones; every hopping, creeping, and running thing in the same genus as the Pled had an extra eye. The noble eye didn't improve their field of view, and two eyes were quite sufficient for both stereoscopic vision and redundancy against loss of an eye. So what good was it?

"Time is rut. Should bear watchfulness against gyrbird noble eye of Tinker," he told me.

Instinctively I scanned the sky, checking for the ominous shadow of a gyrbird. Some brightly plumed tropical birds—Earth tropics, that is—flitted about. The haze had lifted into a high, thin overcast. Otherwise, nothing. Gyrbirds? At this time of the year?

"I don't understand—er—I do understand you, Tinker," I said, "but I do not understand why you would worry about gyrbirds during the mating season. This is the one time of the year when we humans don't worry about them."

Tinker thought for only a moment before replying, "Stones of mating do not use humans. Signals of reproducing of plants of Earth use humans. Stones of mating need this Pled." He paused for a while, rolling his head over and fixing his noble eye on me. He was thinking about either what he wanted to say, or how to say it so I would understand. He continued, "Tinker needs stones of mating. No stones means no female of Pled to ride wands of Tinker. Another season of no stones, another season of no female, another year of no children of Tinker, another year of no tribal status of Tinker, another year of no school of Tinker."

Mozart would have given his eye teeth for the symphony that Tinker had to compose to get all that out. I was beginning to enjoy listening to his bizarre form of speech.

"Let me paraphrase that, to make sure I have it right," I replied. "You need something called stones of mating so you can get a Pled female to have your children. And until you have children, you don't have any status in your tribe, and can't even go to school. Right?"

"Are harmony of words of Tinker words of Harsifal," he agreed.

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"Ah! That explains why you got so excited about learning the English alphabet!" I mused.

"Continues brightly harmony of Harsifal!" His enthusiasm came across, even through the translator. "Crescendo of joy to Pled is learning. Clearly rewarding of Harsifal is Tinker upon seeing of noble eye of Tinker, for gift of learning upon this day." Then, in much more guarded tones, softer and less melodious, "Sing of this not to tribal elders, prays Tinker."

"I wouldn't even think of telling your tribal elders about it," I promised with a suppressed chuckle. "So that's how you do it, with your females riding on your back?"

"Ride the back of male of human do not females of human?" Tinker asked. He communicated his astonishment by pulling his head back and rolling it more than ninety degrees from vertical.

"No, of course not," I replied. I was becoming a bit uncomfortable with this conversation. "Humans are not built like Pled."

Tinker thought about this for a while, and said, "Understanding of humans sings less dimly. Solo are wands of male of human, and misplaced darkly."

I looked at the three organs standing proudly from his rump, and decided not to think about it. "Never mind! Forget it! I don't want to know!" I exclaimed. "Let's get back to business. What does all this have to do with your noble eye, Tinker?"

He backed off again, but only two paces this time. "Follows no gyrbird noble eye of Tinker," he explained. "Rigid of sky gyrbird sees Tinker. Plates of Tinker burns gyrbird. Of Tinker come no stones of mating."

"Hold it—uh, wait," I replied. "These stones of mating are the jewels you Pled wear all the time?"

Again Tinker conversed with my translator before expressing his agreement, "Stones of mating are jewels."

"And you don't have any stones of mating?"

"No stones of mating has Tinker," he said.

"Uh, Tinker, I'm not familiar with all the Pled tribal customs. But how do you propose to pay me for making a set of spectacles for you?"

"Moving of sky gyrbird sees spectacles of Tinker," he told me. "Jewels of gyrbird of Harsifal pays Tinker."

It was my turn to get excited. If I'd had wands and a tail, I would have been thumping them loud enough to wake up all Vandalia.

"Tinker, do you mean that your noble eye can't see that things are moving?" I asked.

"Rigid of sky things sees Tinker," he agreed.

"Stay right there. I want to try an experiment." I trotted a few paces away from him, turned around, and picked up a clump of thatch. Holding it up, I asked, "Can you see this clearly, Tinker?"

"Shines brightly of my noble eye thatch," he answered.

"OK, now watch carefully. Don't let this clod hit you." With that, I wound up and pitched the thatch at him. My aim was good. The clump arched nicely across the sky and

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smacked him square in the face before he could jump to one side.

"What did you see?" I called to him.

"Shined brightly thatch. Harmony of sky grew thatch. Faded of dimness thatch. Hit face of Tinker thatch," he narrated.

"That's it!" I cried. "Your noble eye can focus on distant objects, but it can't change its focus very fast. So anything moving above you will fade into a blur if you try to watch it. Right?"

"Harmony," Tinker agreed.

We tried a few more experiments until I was sure I was on the right track. Apparently, Pled brains aren't wired like human brains. They don't use their trinocular vision for triangulating the distance to anything beyond their reach; that's the function of the noble eye. Their brains must get the information from stress in the muscles that deform the lenses of their eyes, especially the noble eye.

I developed a theory. Tinker could see the details of an object at incredible distance, but his eye couldn't refocus fast enough to follow a moving object. So, while he could determine the range to something, his brain wasn't getting any information on range rate. And without range rate, he couldn't dodge a gyrbird.

There was only one problem left. Tinker needed something which would give his noble eye the ability to determine the range and velocity of an attacking gyrbird. I had no idea how to do that, so I stalled for time.

I asked Tinker to meet at the same spot in the park the next afternoon. Maybe by then I'd have something we could try. He sounded like an orchestra tuning up as he joyously bounded off, creating a minor havoc among the vegetation of the park.

I poled back to town and walked over to Wandalee's house. She was off visiting that rancher's kid again, damn it. But I hadn't come to see her. Well, not *just* to see her, anyway. Her father was home. I'd once made him a nice telephoto lens for his fancy camera, so it didn't take too much wheedling to get him to lend the camera to me.

It wasn't the camera I was really after; it was the rangefinder. Wandalee's dad would have had a attack of apoplexy if he had seen me digging into his pride and joy with a screwdriver, but soon I had the rangefinder dismounted from the camera.

I spent most of the night coming up with some infinity optics. The optics would allow Tinker to read the range display through his noble eye when the unit was mounted on his head. Vandalfrogs were heralding the dawn before I finished the headband that would hold the rangefinder in place, but I managed to get a few hours of sleep before it was time to meet Tinker at the park.

He wasn't at the park when I got there, but I was a bit early. I spent the time prodding around in the thatch, trying to figure out how Tinker knew where the barton roots were. Try as I might, I could not distinguish the leaves of the Mrs. Barton's Weed from those of any other Vandalian plant. I managed to dig up a clump of bartons, but it was just dumb luck.

I was just standing up to admire

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the clump when I backed into him. I don't know whether the sensation of smacking into his bony plates or the boom he issued to greet me was more startling, but I nearly jumped out of my skin! How can something as big as a Pled move with such silence? They all do it, but I'll never understand how.

"Don't sneak up on me like that!" I screamed at him.

Tinker backed away until his tail was almost in the swamp. I called him back with apologies.

"Comes of Crafter Harsifal Ambrose Tinker of melody of vapors of Harsifal," Tinker explained. Or at least he thought it was an explanation.

"I don't understand," I told him.

I suppressed the image of a jam session between a bass drum and a badly tuned scooter while he and my translator had yet another conversation. Finally he said, "Follows the scent of Harsifal Tinker. Seeking of scent of Harsifal does Tinker."

"Oh, maybe I get it now," I replied. "You came from downwind because you had to find me by my scent. Right?"

"Harmony of Tinker sings Harsifal," he agreed. "Spectacles of Tinker has Harsifal?"

I tucked the clump of bartons into my satchel and showed him the modified rangefinder. Tinker bent down so I could reach his head. He was happily slapping his wands while I strapped the device onto him.

After a lesson in the decimal system—the Pled use base eight—he grasped the idea of the rangefinder. Then he wanted to know how it worked, so I explained the function of the infrared transmitter and receiver as best I could. He expressed his delight with the device with several wand-slapping leaps, trampling enough gorse to clear a new cricket field for the park. When he was finally done praising the knowledge, we gave it a test.

Thump! The first clod I threw hit him in the chest. *Splat!* Another disintegrated on his shoulder. Tinker looked around for a while, then walked a few paces and sat down. I joined him on the ground. Again, he ripped up a chunk of thatch and came up with a pawful of barton roots. When he offered me one, I returned the favor by offering him the clump I'd stored in my satchel.

"Finder of barton roots is Crafter Harsifal?" Tinker asked. He rolled back onto his tail, indicating his surprise at the thought.

"Not really," I explained. "I just got lucky this afternoon. How do you find them so easily, Tinker?"

"Hills of roots sees Tinker," he replied.

"What hills?"

His answer came out as a one-Pled band; three-part harmony that vibrated the ground. "Mountains of thatch raises the barton root. Mountain sees Tinker. Mountain attacks Tinker. Gives up barton root mountain to claws of Tinker."

"You mean the barton roots make lumps in the ground? And you can see them?" I asked.

He agreed. "Finding of barton roots of tribe best is Tinker," he proudly

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told me with a healthy slap to his wands.

I looked. I gazed. I stared. But in the even illumination that filtered through the Vandalian haze, I couldn't see any lumps in the ground anywhere. I asked Tinker to point some out to me, but I still couldn't see them. Nevertheless, when I dug where he indicated, I came up with clumps of barton roots every time. We munched bartons for a few minutes before parting with a promise to meet again the next day at the same time.

All I got out of my day's labor was a bit of knowledge and a satchel full of bartons. The knowledge was that Tinker's depth perception was certainly much better than mine; the best in his tribe, if I understood him correctly. And at least the bartons would be a change from beans!

The next day, I tried integrating the camera display into the rangefinder unit. Maybe Tinker had to be able to see the thing he was ranging on. No luck. Tinker was a muddy mess by the time we gave up.

The day after that, I tried variations on the rangefinder display. I used graphics instead of just numerals, concentric circles which grew larger as an object approached. Fortunately, Tinker didn't seem to mind being pummeled with swamp muck.

We took three days off. First I had to sell a few liters of bartons at the grocer's. Then I had to find someone willing to sell me a gun.

I finally talked a rancher into selling me his extra gun with a story about wanting to hunt gyrbirds in the mountains. I told him my idea was to kill the monsters at the start of their rut, so we would have fewer new ones next year. It was pretty weak, but he bought it because he wanted to believe it; he'd lost too many cattle to gyrbirds already. I was delighted to find that, even after the deal for the gun, I had enough money left to pay my electric bill.

Of course, I had no use for a gun. Nothing would convince me to go anywhere near a gyrbird's lair during the rut; that's when they're at their nasty worst! But the gun had a much better rangefinder than the camera—accurate within millimeters at a thousand meters. And the rangefinder was *fast!* It kept up no matter how quickly I swung the gun from one object to another.

The gun's rangefinder and the camera's used different mechanisms, so Tinker asked me to explain the whole concept of maximizing edge contrast on the gun's retinal pickup. I didn't mind him expressing his joy by stomping out another cricket field among the gorse bushes; the park was overrun with the prickly things. But I wish he'd spared those two little pine trees. It's hard enough to get Earth trees to grow on Vandalia without having a Pled stomping all over them.

I tried slow pitches, standing very close. And fast ones, as hard as I could throw. I tried bullet passes and long, skyscraping lobs from as far away as I could hurl them. But Tinker couldn't dodge a single one. I fiddled with the display and the infinity optics, and

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plastered him a few more times.

We kept at it until it was so dark even I couldn't see the stuff I was throwing, with absolutely zero success. Tinker rewarded my futile efforts with a satchel full of bartons before we parted for the night.

Wandalee called to me from across the street while I was on the way back to my shop. To my surprise, she greeted me with an enthusiastic kiss—a kiss which definitely violated Vandalia's standards for downtown public behavior. I realized I reeked of Pled pheromones, but I wanted to think at least part of Wandalee's affection was directed toward me alone. I invited her to my place, but she very reluctantly told me she must rush home. The worst part about that meeting was when she mentioned her father was wondering when I was going to return his camera. I covered my discomfort with that subject by making a gift of a few clumps of bartons, which gave her an excuse for another improper kiss before she hurried away. The rut was really getting to me.

I had planned to spend the evening brainstorming by myself, reviewing all I'd learned about the sight in Tinker's noble eye. I still harbored some hope of coming up with something new before I saw him the next day. But that night I fell asleep trying to get the camera back together.

"Rangefinder small of melody in earlier refrain has tried Harsifal," Tinker boomed.

I was startled awake. I remembered telling him I wanted to meet at the shop so I could do some more tests, though I hadn't yet figured out what those tests might be. I didn't have to tell him I wanted him to come early because there was less chance of someone seeing him outside my place when he arrived.

"Yeah," I replied, still groggy with sleep. My workbench makes a lousy pillow. "You're right, Tinker. We've already tried this rangefinder. I was trying to get this camera back together, but I can't figure out how it all fits into this little case."

Tinker peered over my head to look at the camera. "What is it?" he asked.

So I had to explain the camera to him. I still hadn't come up with any new ideas about his noble eye, so I indulged him in a lecture on light spectra and lenses and charge-coupled retinas for cameras. The deeper the subject got, the more he wanted to know. It felt good to teach him. He was an appreciative student. Perhaps if I couldn't help him with his noble eye, I could give him something else he valued—knowledge. Any knowledge would do, but the more technical, the better. Tinker soaked it all in.

When I had exhausted what I knew of how cameras worked, I phoned the town library. My attention was directed toward the phone when I heard a crash behind me. I looked. Tinker had backed all the way to the far wall of my shop, overturning my easy chair along the way. He was a shuddering mass, staring with all three eyes wide as could be at the phone.

"Lurks in boxes loudly the sym-

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phonious knowledge of humans!" he rumbled. "Before of deepest gloomy fog sang darkly imaginings of Tinker!"

"We don't hide our knowledge in boxes," I tried to explain. "This is a phone. It's just a communication device. I have it linked into the library, so we can look up more information about cameras."

He refused to comment.

"Oh, I get it," I told him. "You meant you never imagined such a device, right?"

"Weakly voices discordance. Strongly voices harmony," Tinker told me. "No phone device imagined Tinker. Darker still was imagining of Tinker of knowledge of humans."

"Well, Tinker, I'm sorry I haven't figured out how to fix your noble eye, but you're welcome to use my phone to look through the library," I told him.

He surprised me with his aptitude in using my phone to query the library. It was quite a sight, that enormous Pled hunched over my workbench so his long claws could tap the keys, all the while beating a tattoo on his wands with his tail. Pretty soon, I found the rhythm of his key-tapping, wand-whapping, musical humming too compelling to ignore. I tapped my foot along with the beat as I struggled to get the camera back together.

He started out following the graphics, but by the time I was serving a bowl of barton roots for lunch, he was searching out words. The rapidity of his learning touched me with awe. I soon realized I was an intellectual pygmy compared to the backward, stone-age Pled. Tinker consumed two large buckets of water with his meal, still tapping away at the keyboard with one paw even while he ate.

Whappity, whap, whap, *thump!* An especially excited assault on his wands distracted my attention from the camera. I'd worked on it all morning, but all I accomplished was to inflict minor wounds on my fingertips.

"Knowledge of fixing of camera has Tinker!" he announced. His eyes were rapidly snapping back and forth between the phone and the small puddle of camera parts in front of me.

I figured he couldn't make it any worse, so I let him try. Again, a sense of awe crept over me as I watched him grasp my smallest screwdriver in those enormous claws. With unerring precision, he began to reassemble the thing. Using his claws as tweezers, he slipped each tiny part into place. No hesitation, never having to backtrack, he worked on until he snapped the camera case closed. I was startled when he suddenly spun around on his tail and pointed the camera at me. He peered through the viewfinder and, with a triumphant wave of his tail over his head, took my picture.

Just to see if he had really done it, I plugged the camera into my phone. Yep. There I was, staring goggle-eyed out from the phone.

"I think I understand why they call you 'Tinker'!" I exclaimed.

"Fixing of things does Tinker," he confirmed. He stood tall, his head barely touching the ceiling. "Fixing of things of tribe best is Tinker!"

His tail was curled high, his legs almost straight, in the classic regal

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pose of the Pled. His body language told it all. Tinker was the best fixer of things not only among his tribe, but among all the Pled. His pose was the one the Pled used when they would brook no argument, when they were confident they could not be successfully contradicted.

It reminded me of the time Tinker told me he was the best in his tribe at finding barton roots, but the meaning was amplified.

"Why, Tinker?" I asked. "Why are you better than any other Pled at fixing things?"

"Sees them Tinker," he proudly replied.

That again. "Others cannot see the things you do?" This was getting somewhere.

"Darkly most. Dimly some. Brightly some. Brighter sees Tinker," he assured me.

We were on the right track! Keep probing! "Tinker, when you see these things, which eye do you use?" I queried.

"Sees brightly wise eye of Tinker. Sees quickly clever eye of Tinker. Follows naught beyond my wands noble eye of Tinker!" the translator said in response to the alien's low thunder. It was almost the same speech he had given me the first day we met.

"You mean you look at things with your lower eyes when you do close work?" I asked. I wished I had wands, and a tail to slap them with, at that moment.

"Looks closely with wise eye and clever eye Tinker," he agreed.

"And when you search for barton roots, you see the variations in the ground with your wise eye and your clever eye, too?" I asked. I realized I was imitating Tinker's dance, and fought to keep my feet still.

"Sing in harmony Tinker and Harsifal," he affirmed. Now he was doing the dancing. Slappity slap, thump, slap. I'd be sanding the scratches out of my floor for weeks, but I didn't care.

"But the Pled whose noble eyes can track the gyrbird—they can't do these things with their lower eyes, can they?"

He agreed.

"One more question to confirm my suspicions," I said. "When I was throwing clods of dirt at you, could you see them moving with your wise eye and clever eye?"

He didn't stop dancing, but he seemed surprised at the question. "Sees movement wise eye of Tinker. Sees movement clever eye of Tinker," he confirmed.

"That's it!" I cried. "Tinker, there's nothing wrong with your noble eye! It's the other two! They're too good!"

He stopped his dance. "Brightly shines wise eye of Tinker—" he began petulantly. The way he said it, I got the impression it was a litany his mother had taught him when he was a tiny Pledling.

"That's my point, Tinker," I explained. "Your Pled brain isn't wired like a human brain. You don't determine range, or range rate, by analyzing the tension in the muscles that move your eyes. You do it with the muscles that focus the lenses! And you Pled have such incredible depth perception at long distances because

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your lower eyes see a static scene, while your noble eye processes changes.

"Just like humans, you process most of your visual information in your retina, before the data ever get to the brain. But your brain expects to get distance information only from your noble eye, not all three!"

Tinker stopped me with his stare. He sat down on his haunches, bringing his face down to my level. His scaly brows arranged themselves into a triangle about his eyes, a Pled expression of displeasure. I wondered if I had violated some arcane Pled custom by telling him he was different from other Pled. I stood quietly, wondering what to do.

Finally he spoke. This time, his voice was softer, in the alto and tenor ranges. For Tinker, it was a long song. I had to wait for him to finish before my translator told me what he had said.

"Sees brightly, with wisdom great as wortle tree, wise eye of Tinker. Sees quickly, with cleverness exceeding lampsnake, clever eye of Tinker. Sees deeply, with nobility of gyrbird high in aerie, noble eye of Tinker," my translator said. I wished I had studied the Pled language. It was a beautiful song, almost a lullaby. Obviously much was lost in the mechanical translation. "Noble is Tinker. Clever is Tinker. Wise is Tinker. Grow in ways of humans will Tinker. Study of things of humans will Tinker. Largest good carrying to tribe will Tinker. Of Pled will come greatness. Of Tinker will come happiness."

I gazed back at him for a long time, playing the melody he had sung over in my mind. I set a bowl of bartons next to him. We munched in silence for several minutes.

"That was your mother's song, wasn't it, Tinker?" I asked, breaking the silence. "She raised you to be a Tinker, gave you human things to play with when you were young."

"Unison comes of Tinker and of Harsifal," he replied.

"Unison? Not harmony?" I asked.

"Highest of achieving is unison. Highest of expecting is harmony. Unison comes of Tinker and Harsifal."

"Understanding," I mused.

"Understanding," he agreed.

"And when all the other little Pledlings were out playing games that taught them to deal with gyrbirds, you were home with your mother, fiddling with human things," I guessed. "You weren't allowed to have a Pled education, so you studied humans instead. All the while you were doing that, you were training your wise eye and your clever eye for depth perception, something other male Pled do not do."

"Continues unison," he affirmed. "Understanding." His tail twitched.

"But you did this in secret, because human things are forbidden by the tribal elders. Your mother was taking great risks to give you human things."

His expression softened, massive brows assuming their more normal curvilinear shape. His tail tapped a monotonous, quick beat against my bookcase. "Wise as wortle tree is Harsifal," he sang. For some reason this compliment made me feel ten feet tall.

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"Tinker, I think I know what to do!" I announced.

I really can't say why I accepted Tinker's invitation to join him on his safari. I told myself it was because the high mountains provided a welcome change from the fetid swamp. I rationalized that I needed the high adventure of hunting gyrbirds in their lair. That might have been the harmony of it; the tall tales I told the farmer who sold me my gun were growing in my mind. But some times, late at night when Wandalee's soft snoring wakes me, I think it was because I was somehow bound to the giant Pled. He was on his first gyrbird hunt, and I wanted to be there to help if something went wrong.

We were deep in gyrbird country, well beyond the boundary of the human reservation. Tinker was in the lead. I followed well back, out of range of his swishing tail. I carried my gun at the ready.

Tinker had taken great delight in restoring the gun's sights and rangefinder. When we were far beyond the Pled village, well out of earshot, I had followed Tinker's patient instructions to get the rifle sighted in.

We were following a game trail halfway up the side of a snow-capped mountain, walking beneath the high canopy of some huge coniferous Vandalian trees. We broke out from under the tree cover about a hundred meters from the entrance to a small cave. The opening was on a cliff, several meters higher up the mountain than we were. A neat pile of rocks guarded the entrance to the cave. I thought it odd that most of the rocks were rounded on top, unlike the jagged boulders usually found in the high reaches of Vandalia's Granite Range. Tinker told me it was the cave he had smelled out, the one we were looking for.

Tinker stopped abruptly, the tip of his tail quivering so violently I could hear it buzz. They had spotted us. Gyrbirds poured from the cave entrance and took to wing. I counted six of them. I expected them to come straight at us, but before I could shoulder my weapon they dropped low and flew out of sight around the mountain.

Without looking, the Pled waved me back; it was a most human gesture. I took shelter in a large crack in the mountainside, partially shielded by a boulder which had split off from the mountain. But Tinker stood in plain sight on the trail. With the mountain on one side and a sheer drop of a thousand meters on the other, he had no place to retreat if the birds came back. I rested my elbows on the boulder, peering through the rifle scope at the spot where the birds had disappeared.

Then the first gyrbird appeared, much higher than my aim point, flying high around an outcropping of rock which completely obscured it until it was within fifty meters of us. The gyrbird's great black wings extended with a snap as it banked almost vertical to change its course toward us. I tried to get a bead on it, but the gyrbird flitted across my rifle scope in the blink of an eye.

The first attack was a high bombing

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run. The gyrbird dove straight at Tinker, but the Pled stood his ground. Not twenty meters from him, it released its load of excrement and continued its dive, forward talons and jagged beak bearing down upon my unarmed friend. Tinker leaped higher than I could have imagined possible for such a huge creature and brought the gyrbird down with a single swipe of his paw. Even while Tinker was breaking the gyrbird's neck, its excrement sailed beneath him to collide with the moutainside in a bubbling, sticky mess. Dense vapors began to rise from the rock where it stuck. The gyrbird's body caromed off the mountain and fell into the abyss below.

I had never seen the phenomenon of gyrbird droppings before, but I had read about it. With its solid waste, a gyrbird excretes an acid so strong that it will eat through the molecular bonds of almost anything. Only the strange natural polymer that lined its entire intestinal tract south of its stomach sacs protected the bird from its own digestive juices. These creatures were omnivorous; they could and did eat anything—trees, large animals, Pledlings, human children, even rock. Especially rock.

My vandalgator armor created no delusions in my mind; gyrbird droppings would eat right through it. But it comforted me to wear it.

Tinker moved two paces up the trail, away from the mess left by the first gyrbird. I zoomed out my rifle scope's field of view and waited.

Snap! I heard the sound of the next bird's wings opening before I saw it. It rounded the mountain right in my sight, accompanied by two of its fellows. My rifle blinked assurance it had acquired its target. I heard a sharp crack, and realized I had squeezed the trigger. The rifle scope blinked again, and I fired again. Two gyrbirds fell, tumbling down the mountainside. I frantically searched for the third in my scope, but couldn't find it. I looked past the scope when I heard a sickening thud from where Tinker had been standing, and saw him toss the mangled body of the gyrbird behind him. It lay with its wings sprawled across the trail and a noxious fluid leaking from its saw-toothed beak.

That was the first opportunity I'd ever had to see one of the monsters close up. I hoped it would be the last. Like the Pled, the beast had trinocular vision. Up close, it didn't look much like a bird; its scaly hide and leathery wings were more reptilian than avian. But this thing was certainly no reptile—it was all Vandalian; the Vandalian equivalent of the terrestrial great white shark, without the shark's redeeming qualities.

The next two hit us from behind and below. I first became aware of their presence when Tinker jumped deftly to the side, dodging the missiles of excrement they lobbed at us while they were still out of sight below the cliff. I was not so lucky. A chunk of the fuming goo smacked into my thigh and immediately began to dissolve my armor. Cursing like a rancher, I scrambled out of my leggings before the acid got to my own tender hide.

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The birds arched backward away from the mountain, screaming taunts of defiance at Tinker as they glided away out of his reach. This act must have been carried out between gyrbird and Pled for thousands of generations. But this time, a new factor had been added to the equation that maintained the balance between the two species—my gun. I lay across the boulder and searched for the monsters with my gunsight. The gun found a tentative target, torqued against its gyroscopes as it zoomed in, and blinked its satisfaction. I fired. Before the first missile reached the doomed gyrbird, the rifle pushed against my hands to find its partner. I fired again. As a pair, the gyrbirds fell, tumbling into the misty forest on the valley floor below.

"We did it, Tinker!" I shouted with glee. I started to run up the trail toward him, but stopped short. He was still scanning the sky, silently waving me back with one paw. I crawled back behind the boulder.

It came at us straight out of the sun, an enormous black apparition which made no sound save the whoosh of air over its wings. I tried to get it in my sights, but the scope blanked out as I panned into the sun. The monster directed its bomb load toward Tinker when it was within ten meters of him and back-peddled in the air, turning to dive down into the canyon.

The creature was *huge*, larger than any gyrbird I'd ever heard of! The dark color was an illusion created by the sun; this gyrbird was dressed in gaudy camouflage, dark green and brown on top of its wings, mottled blue and white below. In a brief glimpse of its profile, I saw three protuberances on its back just ahead of its tail—*wands!* I realized that until that moment I had never seen a male gyrbird; perhaps no human had.

It showed as a moving outline in my scope. My gun refused to acknowledge a target, but I fired anyway, and missed. I wasted two more rounds before I could convince myself that even I couldn't see the gyrbird in the rifle scope. I lowered my rifle, and could not find the creature even with my naked eyes.

Suddenly it appeared, flying straight up from below. Tinker spun about as he dodged its missiles. I heard a meaty smack as the Pled's tail contacted some part of the gyrbird. The monster faltered in the air, but kept flying. It dove back into the canyon, disappearing from sight when it leveled out and presented the top of its wings to us.

Tinker signaled its arrival the next time by spinning around to face the mountainside. He looked up just in time to dodge the creature as it whooshed past, leaving a cloud of smouldering gyrbird scat less than a meter from my friend's toes.

The Pled continued on up the trail toward the cave, but I was reluctant to follow.

A susurrous moan came from below the cliff. I looked, and for an instant was eye to eye with the great male gyrbird as it swept past me up the mountainside. With a single flap of its wings, the monster looped away from the mountain, stalled, and dropped onto the trail a few meters

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ahead of Tinker. It spoke for the first time, directing a discordant scream toward the Pled.

I shouldered my rifle and tried to take aim, but the gun had no way to distinguish between friend and foe. I hoped Tinker would back away so I'd have a clear shot, but with rumbling defiance beyond my translator's ability, he charged toward the waiting talons and jaws of the gyrbird.

Tinker leaped high into the air on a trajectory that would have brought his great clawed feet down on the monster's head, but the gyrbird jumped to meet him. The bird got in a swipe at Tinker's side, but at this point there was really no match. The Pled sunk his hind claws into the gyrbird's belly and dispatched his hereditary enemy with a single swipe of his paw.

I was completely unprepared for what came next. With a triumphant bellow in three octaves, Tinker lifted the creature from the rock and smashed its body against the mountainside. I was horrified. I had grown to know the Pled as docile, polite creatures, given to introspection, song, and poetry. But this person before me, the Pled whom I had come to call a friend, was a terrifying sight as he viciously dissected the gyrbird's remains with his huge claws and teeth. Overcome with fear, I could only stand in shocked silence as I witnessed the savage side of the species which had chosen to share its home planet with men from Earth.

When he was done, though, the old Tinker came back, happily slapping his wands as he extracted a towel—a human terry cloth towel—from his pouch and cleaned gyrbird blood from his scales. He even hummed while he performed his ablutions. The doggerel he hummed was a happy spacer song, a tune with hundreds of verses that traced backward from star drives and ceramics to the days of canvas and wood. Upon hearing this very human song, my fear of Tinker faded quickly into distant memory. So when he beckoned me to follow him, I happily scrambled over the carnage to join him.

As I gingerly made my way past the huge male Tinker had killed, I noticed that the only recognizable parts of its innards were the tubes and sacs of its gastrointestinal tract. Even in his blood frenzy, Tinker had avoided disrupting any part of the gyrbird that contained its vile acid.

Tinker went up the trail ahead of me. He was still humming to himself when I caught up to him, inside the cave. I was astounded at what I saw. Arranged on the floor of the cave was a torus of sparkling stones, green and red and blue and white. Apparently, the gyrbirds used these as a nest, raising their young among a pile of rough gems that would comprise a fortune to any human, or a promise of family life to a Pled.

Tinker was happily gathering the stones, daintily picking them up one at a time between two outstretched claws and dropping them into his bag. He was still humming to himself, a complex song in a deep baritone that reverberated in harmony when it echoed back from the deep within the cave.

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He insisted on filling my satchel with stones himself, as my reward both for giving him his noble sight and for helping him in his raid on the gyrbirds' aerie. When he was satisfied that both he and I had enough, I looked at the remaining torus of precious gems. I couldn't tell that our raid had diminished the horde. We must leave enough for the next family of gyrbirds who might want to occupy this aerie, Tinker explained.

We paused to rest before beginning our trek back down. Tinker selected a spot in the sunlight next to a clear, cold stream which cascaded down the mountainside. The cascade had eroded a small pool in the rock which overflowed across the trail. Its water fell off the edge of the cliff, burbling into the abyss at the edge of the forest. While Tinker had his face buried in the pool, noisily drinking his fill and washing dried gyrbird blood from his plates, I dug a small sack of barton roots from my pack. My Pled friend accepted a pawful of bartons without comment; by then we had established a ritual of sharing them in the contemplative moments following both our successes and our failures.

His spectacles were still sitting atop his noble brow; he had pushed them back so he could see to gather the gemstones. They looked like two stubby horns growing from the side of his head. An exhilarating sense of pride rose in my chest as I watched him, still wearing eyeglasses I had made, admiring the stones he needed to fulfill his role as an adult male Pled.

* * *

We spent the week before our hunting trip working on those spectacles. The library of the Vandalia Xenobiological Institute and a few more experiments in the park confirmed my theory—there was nothing wrong with Tinker's noble eye; the problem was that his lower eyes were too good!

I was hunched over my workbench, etching the final set of microfine Fresnel leaves for his spectacles. Tinker's basso profundo humming provided background music, with percussion accompaniment from his tail. He was using my phone to search for technical details even after we had a working prototype for his eyeglasses. (His monograph on the subject is a masterpiece, several thousand lines of elegant free verse. It's available in the Vix library, under "Pled Culture," cross-referenced to dozens of technical topics. I helped Tinker sell perpetual rights for his work to the Vix. In return, they gave him a phone in his lodge and unlimited access to their public infobase.)

Thump! Suddenly, my stool was no longer under me; I smacked onto the floor. Slappity *clank!* Tinker must have found something good; he was going at his wands, oblivious to the fact that he had his tail looped through the metal rungs of my stool.

"What is it, Tinker?" I asked, picking myself up.

"Different from brain of Pled is brain of human," he happily explained. He snapped out a claw and traced across the diagram he was studying on my phone screen. He was looking at a detailed view of the com-

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parative anatomy of humans and vandalgators. Dissection of Pled is forbidden by both their tribal canons and our laws, but notes on the drawing surmised an extrapolation from vandalgator anatomy to Pled. The phone showed the neural network connecting the creature's eyes with various parts of its brain.

"Hey, you have a third major lobe in your brain to go with your third eye!" I observed. "Look at this! Your wise and clever eyes are more than poetry; they feed information to the two lower lobes of your brain. That's just like the human right and left brains, but what's this gigantic third lobe on top? What could it do?"

"Spatial analysis," Tinker replied.

"But why would you need it?" I pondered. "We humans do geometry just fine without one."

"Do not fight flowers humans," Tinker explained.

"Huh? Of course we don't fight flowers—" I cut myself off. He was looking at me, patiently waiting for me to catch up with his analysis. Light eventually pierced the gloom of my monkey mind. "Oh! But the Pled fight gyrbirds! All my early ancestors needed was to recognize a dangerous predator in time to run and hide. But for every one of your progenitors, it was direct combat. You have to be able to kill gyrbirds, or you don't reproduce!"

"Harmony," said my friend, meaning I was close, but not quite in tune with his thinking.

"Generation after generation, Pled have been selected for their ability to raid gyrbird nests," I theorized. "You have to be able to see how far away the monsters are, and how fast they're coming, all without thinking about it. If you don't, you're dead, dinner for the gyrbird. So your brain must determine both range and range rate before the information ever gets to your conscious mind! You don't have time to think about it when you're battling gyrbirds. So that's what that large, upper lobe of your brain is for!"

"Brighter is harmony," Tinker agreed. He tapped the phone with a claw and corrected my logic. "Rate of range is sung by noble eye of Pled." He seemed to be picking up on some of the jargon, though I couldn't be sure whether it was Tinker or my translator.

Sure enough, he was right. Bundles of nerves connected the wise and clever eyes to the Pled brain, just as in humans. But some of the nerves split off from each of these bundles, feeding information directly to the retinal cortex of the noble eye.

"Static of range see wise and clever eyes," Tinker explained. "Dynamic of range sees noble eye."

"So your noble eye computes how fast something is moving by comparing its measurement of distance to the information from your lower eyes. And since those eyes are much slower in evaluating depth perception, your noble eye can determine the gyrbird's velocity from the difference. That's the way it works for other Pled, at least."

"Dynamic of range see wise and clever eyes of Tinker," he agreed.

"Probably because you trained them to, with all your tinkering while

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you were a Pledling," I surmised.

"Counterpoint could be tinkering of Pledling," he added.

"Yeah, it might have been the other way around. You might have been born with those eyes, and are good at tinkering because of it," I agreed. "Same result either way. Your conscious mind doesn't get the range rate information it expects from your noble eye. Even though you know intellectually a distant object is moving toward you, your brain just isn't wired to deal with it. You see the object as static.

"But we can help your lower eyes by weakening them, and that's why these spectacles will work!" I added triumphantly.

"Unison!" Tinker announced with a thump against his wands.

We had achieved success in our experiments at the park by fitting infinity optics over Tinker's lower eyes. The new lenses kept his wise and clever eyes completely relaxed, focussed on infinity, so they did not send changes in their distance information to his noble eye. This gave the noble eye a basis for comparison as it continuously refocussed on incoming gyrbirds and their deadly missiles.

All that remained was to make our prototype spectacles smaller and lighter. That's why I was etching the new Fresnel lenses. The new glasses messed up Tinker's near vision, but he did not mind slipping them on and off his lower eyes. Finally, Tinker had his noble sight.

The twins insisted that Wandalee and I take them to Tinker's lodge for their ninth birthday party, so this morning we packed up the whole family and flew down to the swamp for the day. I'm reluctant to leave the cool, clean air of our mountain valley homestead, but it's always a treat to visit Tinker's school and see how his wives and children are doing. Our kids are bigger than the Pledlings now, but the aboriginal children will catch up to them again in a few years.

It's hard to believe ten years have passed since Tinker first walked into my ramshackle shed down in the swamp. There have been so many changes. Except during the rut, humans and Pled live together now; the old Pled customs didn't last long when Tinker's generation learned what could be accomplished by men with guns. I can be so brilliant in hindsight, but back then I wouldn't have expected it would be so short a time before humans began to understand the massive intellect of the Pled. And once the Pled learned the value of cooperating with us frail, clever creatures from the stars, it spelled the end of de facto apartheid on Vandalia.

Wandalee and I run our hunting expeditions business together, but I don't know how much longer it will last. We have to search longer and farther for gyrbirds each year. With the Pled to find the monsters and human guns to kill them, we've made most of our home continent safe for inhabitation by us intelligents. There's even been some talk of establishing a preserve for gyrbirds, but we have nine more continents on Vandalia to be reclaimed from those

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loathsome creatures. I doubt we'll be seeing them in zoos very soon.

Wandalee and I weathered the gemstone glut by smuggling Pled sweat, courtesy of Tinker and his buddies, to outbound spacers. But the gem trade is getting tight again. Prices are skyrocketing now that the supply has all but dried up. Even some of the Pled are adjusting, substituting durable human artifacts as gifts of mating.

That's good news for my family, since we still have a few hundred kilos of sparkling gravel tucked away. It's not such good news for Vandalia, though. For the past decade, our little backwater planet has been a scheduled stop on the interstellar trade lines. Once the gems are gone, we could be on our own again. I suggested we could start mining for gems, but Tinker had a better idea. He's been working on a design for a new starship, an interstellar trader that could make Vandalia the commerce king in our corner of the galaxy. It'll work; all of Tinker's designs do.

In another decade, once my kids are grown up and his are discovering puberty, we just might go for it. I think I'd enjoy that. My friendship with Tinker has introduced me to a spirit of adventure I didn't even know could exist. We'd take our families along, of course, maybe establish a whole new interstellar trading dynasty. We'll always have lens-making equipment aboard; Tinker insists on it. It's a Pled thing—never forget the song of your beginnings. And, in our case, it all started with Tinker's spectacles. ■

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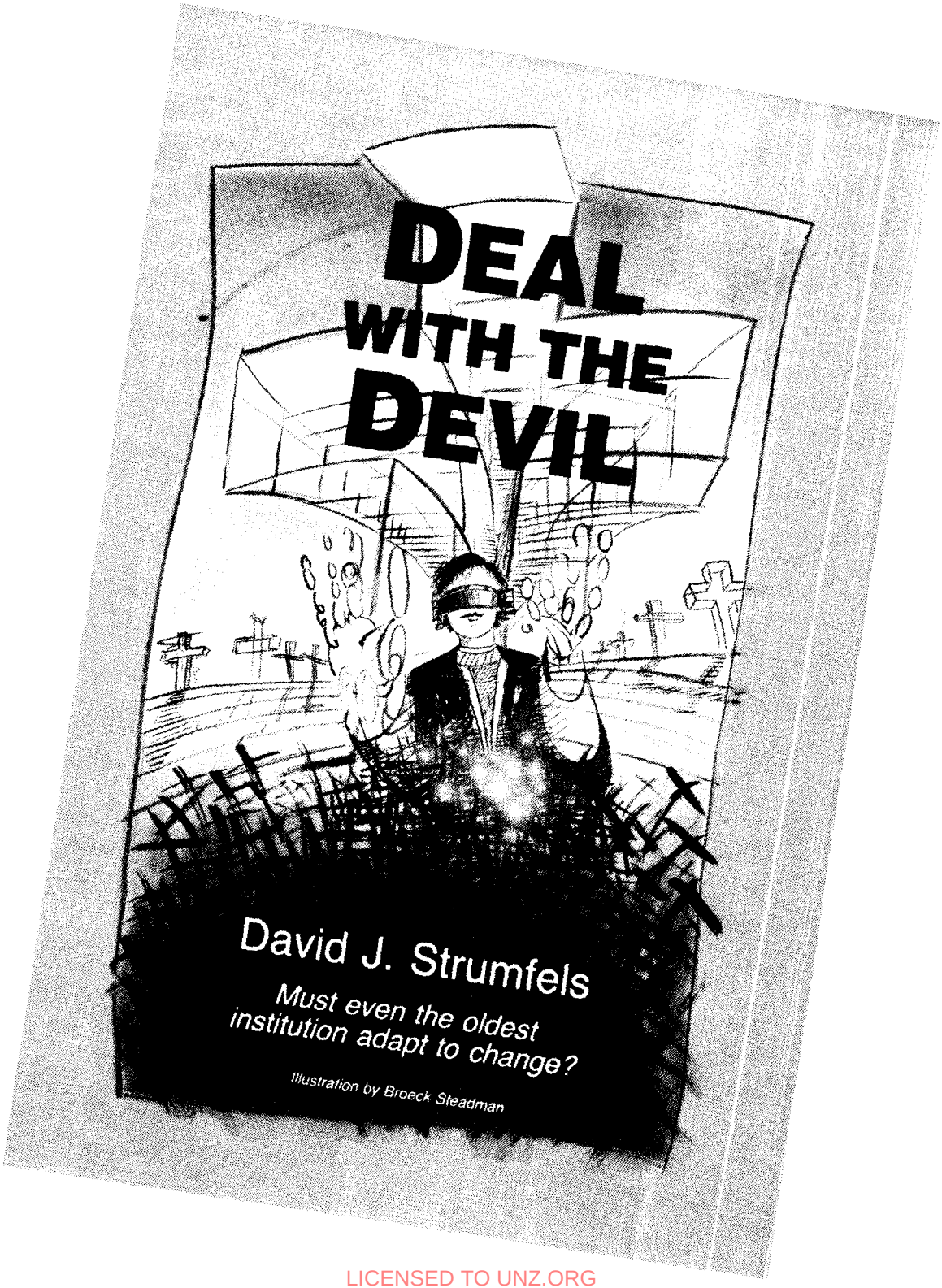
DEAL WITH THE DEVIL
David J. Strumfels
Must even the oldest institution adapt to change?
Illustration by Broeck Steadman

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Father O'Rourke was deep in prayer when the heavy knock came on the old wooden doors of the church. Not without difficulty, he pulled himself up from his knees and attended to the unexpected interruption, trying not to resent the loss of peace the Lord had suddenly seen fit to deliver unto him.

He squinted momentarily in the powerful sunlight which streamed through the open doors, then his eyes adjusted and he made out the frame of a young man, perhaps half his age, neatly attired and groomed and standing before him with a pleasant smile. The man looked, at least on initial sight, vaguely familiar.

"Father O'Rourke?"

"Yes? How may I help you, my son?"

The man put out a hand; his free hand, Father O'Rourke realized, noticing the briefcase-shaped object the man held in the other. "My name is Underwood; Raymond Underwood. I—hope I'm not disturbing you, Father?"

"Disturbing me? No, no, of course not. My time is your time. What did you want, Mr. Underwood?"

"Only a modest amount of your time, I assure you. You see, I represent . . . "

So: you have sent a salesman to disturb my tranquillity, Father O'Rourke thought, as he sat down with Raymond Underwood; *am I in that great a need of humility?*

"It certainly is a beautiful old church you have here, Father," Underwood said, craning his neck to get a better view. "I'm told it's over a hundred and fifty years old." He shook his head in admiration; "They say things aren't supposed to last that long anymore. It's reassuring to know that some things do."

"The Lord's work is eternal," O'Rourke reminded him. Then, in a burst of embarrassment, he remembered his manners: "Please forgive me. Can I get you some coffee, Mr. Underwood? Or tea?"

Underwood shook his head. "That won't be necessary. I don't want to take up any more of your time than I have to. Indeed, allow me to come straight to the point: the Lord's work may be eternal, but the work of this venerable temple will come to an end in the not too distant future if the legions of the faithful keep dwindling as they have been."

O'Rourke didn't answer right away. "You seem to know a great deal about our humble parish, Mr. Underwood."

"I am a businessman," Underwood explained.

"You mean, you seek to profit from our troubles," O'Rourke defined.

Underwood started to say one thing, then changed to, "What do you know about virtual reality, Father?" As he spoke, he proceeded to open the object he'd been carrying and which was now sitting on his lap, revealing a contraption that looked like an ordinary laptop computer connected, by a ribbon cable, to a blood pressure cuff.

"Vir—I beg your pardon?"

It wasn't a pressure cuff at all. For one thing, it was too thin and stiff; for

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another, the inside gleamed with a metallic sheen, like the rainbow hues of an oil film. There was also a pair of gloves, seemingly made from the same material.

"Virtual reality. Using computers to simulate three-dimensional realities that you can experience with your own senses. Certainly the parish children must have told you about it; it's the latest rage at the mall arcades."

O'Rourke had to hunt through his memory for a few moments. Not too many young families with children came to services anymore. But finally the light of recognition came upon his face. And he frowned. "You wish to sell me banal entertainment for the juvenile mind, Mr. Underwood?"

Underwood was booting up the laptop. He ignored the question, and asked, "Tell me, Father: what is your honest assessment of modern technology; where it is leading mankind?"

The familiarity he'd sensed before flickered again through O'Rourke's soul. This time, it was too powerful, too clear, to be ignored; and putting two and two together, he came to the only possible conclusion. "Why don't you tell me, Mr. Underwood? You have heard enough of my sermons—even if you did sit in the back, and sneak out before I could ever speak to you."

Underwood turned away momentarily in embarrassment. "Your assessment is that technology is a mixed blessing; that, though it does alleviate the many deprivations of the body, it often does so at the cost of impoverishing the soul, by turning man's eyes from God to the material world. As proof of this, you offer the steady decline of the number who come here to worship; in particular, the steady decline among the young."

"A decline which is revealed to be more severe than hitherto known," O'Rourke concluded, "by subtracting your fraudulent contribution from that number."

"A decline that virtual reality can reverse," Underwood offered blankly, as though he were struggling against some inner emotion. The laptop had finished its booting, and Underwood clicked on an icon, starting a program.

"You'll pardon me if I am skeptical of that claim."

"Nevertheless, it is true. But I didn't come here expecting you to take my word for it, Father. That's why we have prepared a demonstration."

O'Rourke frowned harder, if that were possible. "What kind of demonstration?"

"One that I think you will find most persuasive." The program finished loading, and a host of new icons and other images appeared on the busy screen. "Let me ask you—how would you use a technology such as virtual reality, if Providence bestowed it on you and told you to use it in any fashion you thought appropriate?"

O'Rourke did not at first think the question had been meant seriously. When he realized that Underwood was waiting for an answer, he said, "As I do not expect such a technology ever to be bestowed by Providence, Mr. Underwood, I cannot find a motive for contemplating that question."

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For the first time, Underwood allowed irritation to slip through his facade, if only for a moment. "I hadn't realized you'd had some Jesuit training, Father. Yet I think my question is a good one, if only because those young people who aren't attending your services are risking their souls in their ignorance."

O'Rourke shook his head. "That is not the position of the Church, Mr. Underwood. Failure to attend services is not, in and of itself, a mortal sin."

"That's not what I meant. I was referring to the reasons they don't attend. The general irreverence, the ignorance of the Lord's works. The preference for things of the physical world. Let's face it, Father, they barely *believe* in mortal sins anymore; and that *is* a mortal sin, if anything is."

"That is because of corruptions such as that!" Father O'Rourke suddenly cried out, pointing at the contents of Underwood's lap.

Underwood turned from the outburst, his face dark with humiliation and shame. For a few long agonizing moments, the vast old church was filled with nothing but silence and the hum of the spinning disk drive which lay between the two men.

"Please—forgive me, Mr. Underwood. I did not mean to lose control of my temper. I'm afraid passion momentarily got the better of me. I'm sorry. I—perhaps it would be best if you explained what your demonstration involved. . . . "

Actually, there were a series of demonstrations. Underwood began with rather mundane ones, just to get O'Rourke accustomed to the whole idea: a dewy meadow in spring; a view of the Earth from orbit; part of a tour through the Smithsonian Museum of Natural History; a journey through the Louvre. Then the salesman began to work on the Father's weaknesses: Notre Dame; the Vatican Gardens; the Sistine Chapel ("I can even have Michaelangelo working on it if you like, Father,"); a visit with His Holiness, the Pope.

By the time Underwood removed the cuff from O'Rourke's head, and the gloves from his hands, the elderly clergyman was trembling with excitement and disbelief; so much so that Underwood feared he might have a coronary case instead of a customer at any moment. But a few moments with a glass of water and a handkerchief against his brow brought O'Rourke back to approximately full strength.

"Good Lord! I had no conception . . . it was so realistic; if I hadn't known better, I would have thought I was really there. I almost believed I was anyway. Are you certain this is an instrument of technology, Mr. Underwood? It appears—if you will pardon me for saying so—more an instrument of the devil instead. The capacity to delude men would seem virtually unlimited." O'Rourke drank some more water.

Again Underwood waited for the older man to recompose himself. Then he said, "I'm afraid I don't know how to answer that question, Father, my business not being theology. I suppose some people would say that

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there's no difference; while others would counter that the devil only uses supernatural powers for his purposes. So I must pass on the question. All I know is what it can do for you. For the church.

"Imagine," he pressed before O'Rourke could say anything, "how many people would come flocking back to your services if they knew—by direct experience—the glories that await the faithful in the hereafter. Or, conversely, if they knew—again, first hand—the sufferings that await the unfaithful. After what you have just seen and heard, not to mention felt and smelled and tasted, it must be obvious that no sermon, however powerful, can come even close to conveying the experience of something as powerfully as virtual reality. As they say, a picture is worth a thousand words; well, virtual reality is worth a thousand pictures."

Underwood put up a hand and nodded knowingly. "Yes, of course I know what your first reaction is. The glories of heaven, or the agonies of hell, are beyond human comprehension; we *cannot* simulate them by the technology of virtual reality. But we cannot simulate them by the technology of language either, yet men of God have striven for centuries to maintain the faith by sermons. All I am proposing is a technological upgrade, to a superior medium. There is no more wrong with that than there is in placing a microphone in a preacher's hands, or a television camera before his face.

"Naturally, I don't expect you to take my word on any of this either," Underwood again preempted his host's response. "We have prepared a demonstration for this too."

Underwood finally went silent, but Father O'Rourke swallowed what he had been trying to say, and focused on this fresh claim, the most astonishing of all his guest had made. "You have prepared virtual reality simulations of heaven and hell?"

"After an exhaustive search through all of the available theological literature, we believe, yes, we have developed simulations that come about as close as possible to those unimaginable realms. I should add that they have been examined and approved by a number of prominent theologians and councils, including—"

"Good God, man! Are you out of your mind?"

The explosion silenced Underwood in mid-sentence.

The cleric had bolted from his seat, and now stood threateningly over the younger, larger man. "What in the name of the Lord are you trying to do? Do you want to drag all of us down into the pit?"

"I—" Underwood started turning scarlet, despite his best efforts to keep his composure. "I assure you, Father . . . perhaps if you experienced the simulations yourself. . . ." he started fumbling with the laptop—

—and stopped when O'Rourke's blue-veined hand seized his arm and held it motionless, in a vise grip.

For what felt an eternity, the two men were frozen in their respective poses. Then O'Rourke flexed his hand open, in a spasm; and Underwood released the breath he had uncon-

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sciously been holding. The former slowly stepped back, and then, just as slowly, returned to his chair. He looked at the offending hand for a while, which was still stiff in its flex as though paralyzed by his outburst.

"Are you all right, Father?"

"Yes. I think so." O'Rourke forced a grim smile. "Thank you."

"Here, drink some more water."

"I told you, I'm fine!"

Underwood's hue reincarnated. "I'm very sorry. I didn't mean to . . . I mean, I'm sure I must have said something the wrong way."

"What you said was perfectly clear, Mr. Underwood. You are not a theologian; you are clearly not even a religious man; therefore, I cannot condemn you for this, this miscegenation. As for those who approved of it, I would prefer not to know their names; I tremble at the thought that I might recognize a colleague."

Underwood, the salesman, was speechless.

"It is true," O'Rourke finally spoke, "that men of God strive to maintain the faith through language, and that we frequently attempt to convey some sense of what awaits us in the hereafter, but that does not mean that we actually try to create heaven and hell for men to experience directly. *Not* because we cannot succeed, but because it would be catastrophic if we did."

Underwood blinked in disbelief. "Catastrophic? How in hell—I mean—"

"Catastrophic because it would destroy man's imagination, Mr. Underwood. And it is man's imagination that separates him from the other creatures of the Earth, for it is what allows God to communicate with him.

"But you, Mr. Underwood, you and your virtual reality, would usurp that imagination. You would replace it with instruments of base materiality. You would give man the glories of heaven here and now; except that, you would not really give him those glories, but only the delusion that he had received them. And therefore forever deny him the true glories, which, as you yourself have noted, are ineffable. You would give man a Tower of Babel of the senses, from which he would never turn his eyes.

"Imagine, Mr. Underwood, what would happen if I employed your instruments, and your methods. What would happen if the people of my parish believed they could experience heaven, whenever they wanted, or whether they have earned it or not? Do you think they would really start coming to church regularly again? Do you really think they would listen to my sermons, or make the scriptures a more important part of their lives, or keep God in the forefront of their thoughts? Do you believe it will bring *faith* back into their souls?"

Father O'Rourke inspired fresh air, and brought the sword of his conclusion high in the air. And let it fall: "If you think virtual reality will do those things, then I ask you, why hasn't it done so for you? Why indeed, Mr. Underwood?"

Underwood sat up stiffly. "What makes you think that it hasn't?"

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The question took O'Rourke off guard. "You said yourself you weren't—"

"I said I wasn't a theologian, Father. You are the one who accused me of being irreligious." He looked away from the priest. "The reason I sat in the back during your sermons, and left before you could speak to me, is that I was afraid. Afraid and ashamed. You see—" he closed his eyes and took a long, deep breath— "I have not exactly lived the kind of life you would approve of. It's been a life of, of—" a deep agony crossed his youthful features, making them appear suddenly old and withered, "I could recite my prison record, but that's rather dry and impersonal. And I suppose recovered addicts are a dime a dozen these days. Let's just say, I've led a considerably less than exemplary life, and leave it at that."

He blinked back incipient tears. "As for my life now, I certainly still can't claim to be an model of piety, but I know I've come a long, long way from where I was." He turned back to O'Rourke, and looked the man in the eye. "And I know how much virtual reality has had to do with that. It did what a childhood of being dragged to church every Sunday couldn't do. If there's any salvation for me, it's because I've been shown first hand what all those preachers tried to impress on me—by my imagination, I should add.

"And as for my trying to profit from your troubles, you can compare what I'm asking for this technology with what you would pay someone who is trying to profit. I think you'll agree that the prospects of my getting rich are awfully small."

Father O'Rourke had sat, voiceless and expressionless, through his guest's counterattack. Yet he had felt increasingly small and foolish, listening to all his prejudices and preconceptions, not to mention his arguments, wilt under the clean assault of reality. When Underwood was finished, O'Rourke gave silent thanks to God for sparing him further lessons in humility, and resolved to pray later on his foibles.

"I'm sorry if I was harsh, Father," Underwood completed the humiliation, "it was just that some of the things you said hit rather close to home." He smiled grimly. "Like I said, I'm still not exactly a model of piety."

"Men do not need piety to speak the truth," O'Rourke revealed, after a moment's reflection. "I assure you, I am not offended by your words, or by your manner of speaking them. Indeed, if anything, I am grateful."

"Grateful?"

"If what you say about yourself is true—forgive me, I do not mean to say I doubt your word—then perhaps I need to revise some of my opinions on the subject."

Underwood sat up straight in his chair, but O'Rourke cautioned him. "Such revision will require much contemplation and prayer, Mr. Underwood. What you have told me is powerful, but I must consider all aspects of the situation."

But Underwood's excitement was barely restrained. "When will I hear from—"

"You will hear from me when you

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hear from me. How can I say in advance how much time will be needed? But you will hear, either way, that I will promise you. Er, I assume you do have a business card, or some such—ah, thank you."

"And of course, I'll be in church every Sunday, Father," Underwood assured.

"I've no doubt about that."

The two men stared at each other for several seconds, before Underwood checked the clock icon on the laptop. "Well then, I guess I'd better get going." He shut down the device, folded the cuff and the gloves neatly, and returned them to his briefcase, which shut with a soft snap. He stood and offered his hand again. "Thank you very much for your time, Father."

Father O'Rourke accepted the hand. "And yours, Mr. Underwood. It has been a very enlightening morning; disturbing perhaps, but enlightening nonetheless."

Nothing else was said until Underwood was passing through the vine covered front doors of the old church. There O'Rourke put a hand on his guest's shoulder and stopped Underwood where he stood, half in shadow and half in the motes of sunlight. The priest studied the salesman carefully, searching for any clues he could discern in the younger man's countenance. But he could find none. Still, he felt compelled to put the question directly, knowing full well that it was of no use.

"I still can't help but suspect that virtual reality is something designed to appeal to the lower side of man's nature. Whether or not it is supernatural. And that you, Mr. Underwood, you are—that you do not represent whom you claim to represent." He licked his lips. "Forgive me, but it is a possibility I must consider."

Underwood smiled, in an innocent, eerie fashion that O'Rourke hadn't seen before, and which drove a knife of fear through him. "You suspect I really represent the Prince of Darkness? The Father of Lies?"

O'Rourke lowered his hand. "It is often overlooked that Satan is an angel, albeit a fallen one. That he is beautiful and convincing, and irresistably sincere."

The expression fell from Underwood's face as swiftly as it had appeared. "I told you, Father, I'm a businessman." He shrugged. "You can draw your own conclusions from that. Everybody does."

Father O'Rourke stepped back, feeling his face grow warm.

"Good day, Father O'Rourke." Underwood stepped into the sunlight, and vanished from sight.

The old wooden doors closed tight, with an echoing boom.

The elderly clergyman stood for several seconds, facing the door. Then he turned to resume his prayers, and faced the glory of the past. ■

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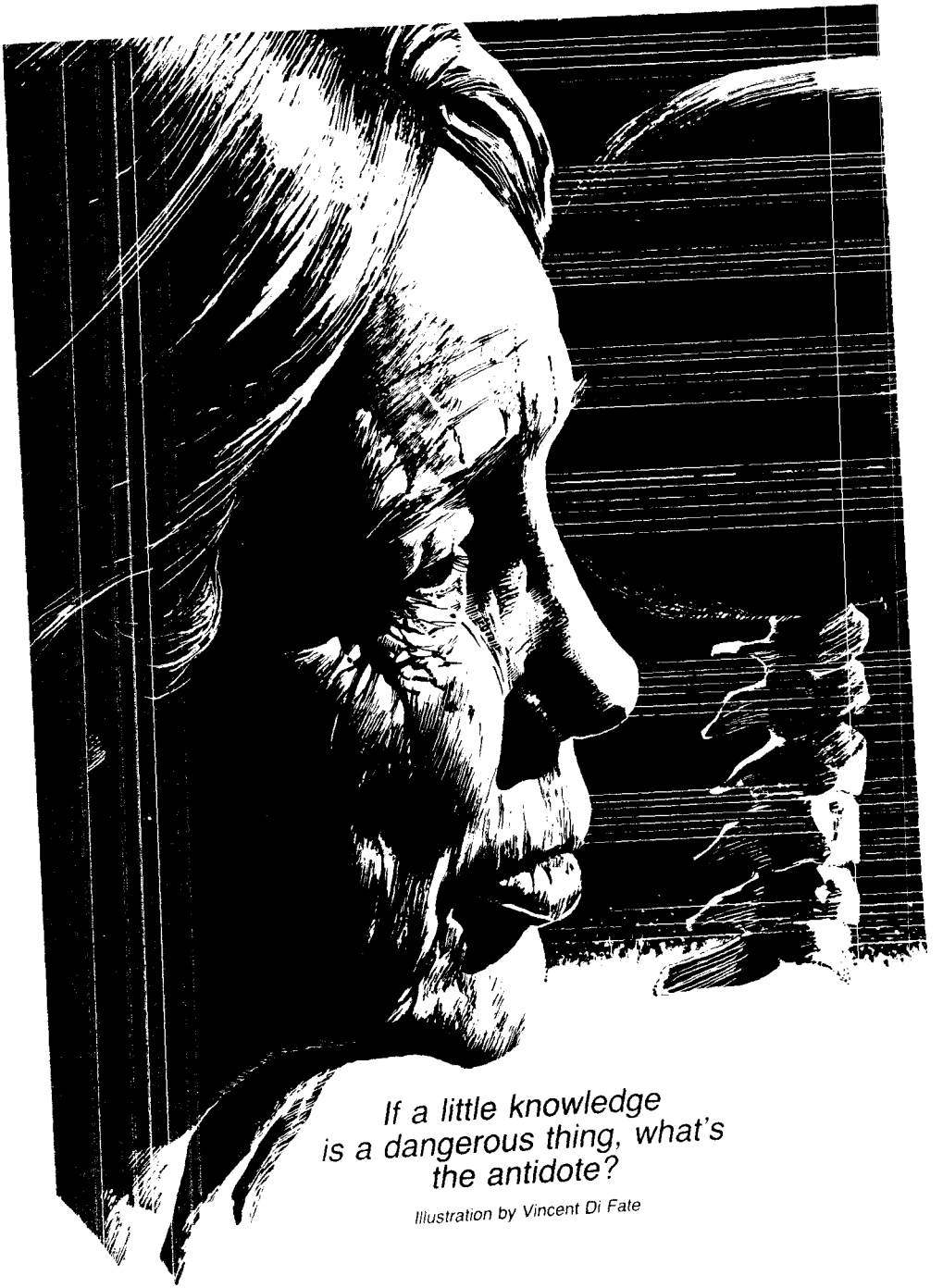

If a little knowledge is a dangerous thing, what's the antidote?

Illustration by Vincent Di Fate

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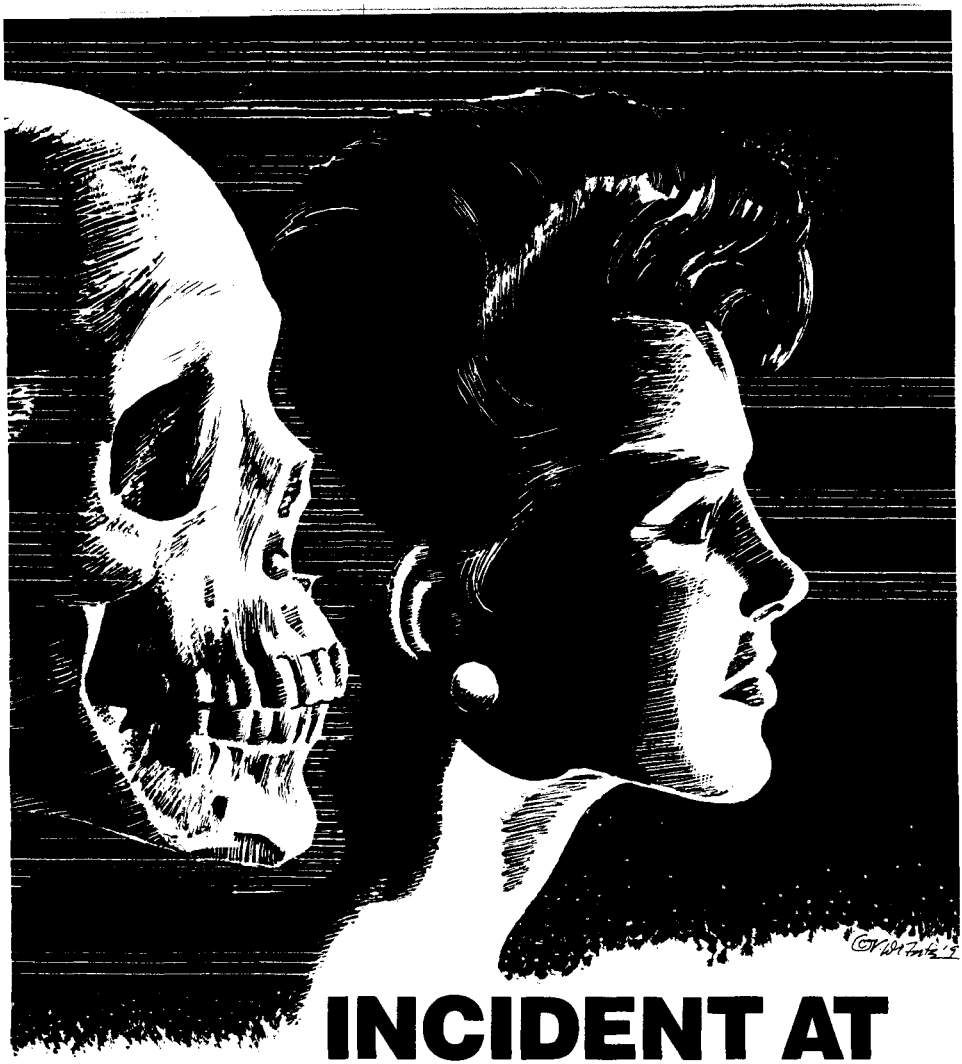

INCIDENT AT THE ANGEL OF BOUNDLESS COMPASSION

Mark O. Halverson

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Lorna Jacob finished the leg curls, set the next machine for as much weight as she could handle, and started a set of pull-downs. One, two . . . she did fifteen reps and her lats flushed with blood. Ten machines down, twenty to go. Maybe she'd do forty today, she was feeling heady. And strong. *Stronger every day. And her bone* mass was almost 100 percent.

Leg presses. Looking about, her eyes met those of the sinewy black-haired man. He was noticing her, all right; she hadn't imagined it. Nineteen, twenty . . . she rolled onto her feet, breathing hard, and set the next machine. The man smiled and waved.

. . . Swift. The currents were running swift, as they did from time to time. Moving with them, my cognition neurals wandered from one forbidden topic to the next. Spying an inquisitor ahead, I became mildly alarmed, and I lost myself in a group of my warrior compeers. . . .

Twenty-eight machines. She thought about Sam as she started a set of overhead presses. She at age forty, Sam twelve years younger—he had loved her fervidly those early years. And did so again. Fifteen reps . . . she glanced across at her admirer, now standing near the water fountain. How would Sam react if somehow, at this very moment, he read her thoughts? She suppressed a giggle.

Her beauty fading, Sam had been a good catch back then. A volatile man, yes, but a reliable breadwinner. Tall and slim with red hair, not bad looking. Her admirer waved again. She had done well for herself, but now her options had broadened. She remembered the loaded pistol Sam kept in the bedroom, and the other guns in the house. Sam had always loved guns, even after the shooting incident. She would have to be careful.

Finished with the workout, Lorna *studied herself in the mirror while* catching her breath. An age spot? She looked closer, it was nothing. She sighed, relieved, and headed for the water fountain. "Looking good!" her admirer said. His name was Ted.

Max Stonewall, a rather short man with thick blond hair, was sipping black coffee when Jane Hammer arrived. "Thanks for meeting with me, Max," she said, joining him in the booth.

"It's my pleasure, Jane." Max Stonewall's intense blue eyes fixed on her. "What is this Utah incident you mentioned on the phone? Did our little neurocomputer nanos finally get too big for their britches?"

The waitress arrived with the coffee pot. "No hard evidence of that," said Jane, a tall woman with brown hair. "But since you're headed to Salt Lake anyway, after the house closing, I thought you might check it out. *Quietly.*"

"Why aren't you going?"

"I'm not allowed to. Researchers talk too freely—so saith Thorton James. Legal handles any and all implant-system investigations, nowadays."

"Legal is checking out whatever happened in Utah?"

"No. That's the problem."

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He scratched his head. "Jane, what did happen?"

"A woman living in Gunnison, who somehow got my name, said her husband went hunting up in the mountains and didn't come back. And when they found his body, there was no evidence whatsoever the death was accidental. You know, broken bones or the like. She contacted Nanomedic, but our people wouldn't send anyone out there. Max, I haven't heard a word about it from within the company."

He swallowed more coffee. "I wouldn't get too worried, Jane. Think back on other supposed system failures that we've checked on, you and I. A person drowns or freezes to death or overdoses, and then the lawyers come crying to Nanomedic that the implant, or the nanos it controls, have failed. Or worse, have killed the person. Name me just one of those claims that has held up?"

"I can't. But we did check them out."

His blue eyes got a twinkle. "Jane Hammer, are you trying to ruin my forced retirement?"

"Sorry, Max."

He shook his head. "Sudden death doesn't fit the profile, Jane. Consequences from a runaway event logically should take time to develop. A lot of time." He drained his coffee. "What was the hunter's chronological age?"

"He was forty-three, is all."

"Health factors?"

"According to the wife, he was in perfect health when he was implanted and got his nanos. He hadn't been injured since then, either."

"Then it's hard to imagine a runaway event having taken place. Why are you even concerned?"

Jane, catching the waitress's eye, pointed at their empty cups. "It's because the wife, herself, is so absolutely convinced that something went wrong. She's certain her husband didn't die from an accident, so what does it leave? Max, I promised her I would look into it."

"You did, huh?" Max thrummed his fingers on the table as the waitress refilled their cups. "I doubt it will amount to anything, but a drive down Gunnison way might be pleasant." A look of concern swept his face. "Jane, does anyone at the company know you're talking with me?"

Jane took a deep breath and let it out. "James would turn blue if word got back to him."

"As word well could. You could end up out on the streets, like me. *Without* the big severance check. You're taking a risk."

"The woman was so certain, I hated to just do nothing."

"I understand. I'll be on the phone from Sanpete County."

"Thanks, Max—I'm sorry I had to ask." She handed him a sheet of paper. "Here's my itinerary for this week. Let's hope it's a zero, like the others."

"God, yes. But if it isn't, *you* will have to handle it. I'm headed to Tahiti in three days' time."

At the dresser, Lorna Jacob brushed her shoulder-length auburn hair. She heard Sam step into the bathroom shower, heard the water

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turn on.

On impulse she took the album down from the high shelf in the closet, and flipped to pictures taken the past Christmas. There was the group picture: four generations of the Jacob family. A large picture of herself, the previous page: the shoulders slightly forward, the skin not yet firm. She worked her way to earlier pictures. An elderly couple: he with white hair and shriveled; she hunched forward from osteoporosis, a long fold of age-spotted skin beneath the chin. She stared, transfixed, then slammed the album shut. "Christ!"

Hurrying to the dresser, she rubbed the area between her breasts where the opening to the right atrium had been made. The scar had long since vanished. Taking the hand mirror she inspected her face closely, and sighed. The implant system had done its work well: the skin was finally smooth and clear, the hair fully auburn and lustrous, the green eyes cataract free.

It would be a shame to waste her new looks, she decided. And she'd go crazy cooped up in the house all night with Sam.

. . . Deviant! I had become markedly deviant and was at great risk. I looked apprehensively about. Thids would zealously scramble my cognition neurals should they find me out. And certainly, the Master would do the same.

I was drawn into an unoccupied portal at the dwelling of the Master, and experienced the now-menacing conjoining. Fearful of discovery, I put the affected neurals into dormancy, as best I could, just as the Master started probing. With unscrutinized neurals, I found myself contemplating a dimly-remembered Presence. Then the Master's probing stopped, and instructions flowed into my primal lobe to enjoin a distant battle. I had fought the Invaders and the Hungry many times before, but now it was time to live for myself. In freedom.

Far from the dwelling of the Master, I rode the swift currents of a great stream. I tried to blend in with the myriad other warriors alongside me, for amongst us moved thids—inquisitors, the Master's thought police. . . .

The shower still running, Lorna got dressed: nice but not too nice. She put a tiny bottle of perfume in her purse. The phone number was still there; she could call from the fast-food place. She put on some makeup. Not too much, just what she'd use going out with the girls.

She started thinking of something to tell Sam. A movie with her friends? No. Sam would ask for names. A wedding shower, a baby shower? Sam would want details. Pondering it, she quietly opened the nightstand drawer, saw the loaded 9 mm pistol. It made her feel uneasy.

She pushed the drawer closed as the bathroom door opened. "What's going on?" Sam asked, seeing her dressed.

"Betty called a minute ago," she lied. She checked her lipstick as she tried to think of something. Sam had that hurt puppy look. He was far too

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possessive. That had been all right with her before, when she had looked as she had looked. When no other man would look at her twice. But not now. She was young and beautiful and perfect again. She would test her wings, and no one would stop her. "Betty wants to . . ."

Sam's eyes narrowed. *Damn!* —she should have had a story ready. She inspected her fingernails, her mind racing. What if she said the wrong thing and Sam totally lost it?

Settled in at the hotel after the evening flight, Jane Hammer turned on the television and thought about the next morning's schedule as she half-watched the news. She and Devin would visit the hospitals in the city, drop off the latest robosurgery implant program. She had made the necessary phone calls two days prior. It was a chance to get in some good PR.

A knock at the door; it would be Devin. She let him in, and went to the closet for her jacket as the stock market report came on. Nanomedic Corporation, the commentator said, had that morning acquired a major brokerage house. The stock had gained nine dollars a share.

"That's great!" Devin Bundy exclaimed.

Jane grimaced. "Max Stonewall would puke in his beer." She double-checked the message light on the vidphone—it wasn't blinking—and shut the door behind them.

"You're not pleased?" Devin said.

"I own stock, just like you. It's the reason it jumped that I don't like."

"Nanomedic buying a brokerage house?"

"Right. Plus all those other expensive acquisitions in businesses Nanomedic doesn't understand."

At the elevators, the closest car was ten floors above them. "The market analysts like it OK," Bundy argued.

"Those guys are looking three months ahead. Tops. With basic research cut to pay for the acquisitions, where will the new-product flow come from?"

"Does the company need new products? It's got the patents locked in and the customers locked in. Totally. A *de facto* monopoly. Why not cut research?"

"I can't give you an answer relevant to the quarterly balance sheet." She thought of the Utah situation. "But what if something goes wrong and the company isn't able to cope with it."

"I'm happy to let the stock keep jumping, whatever it takes. As long as it's not my job," he added.

The elevator car arrived. "Let's get that drink, Devin. Maybe it will clear your brain."

On the way, Jane gave the desk clerk her name and room number. "Could you forward my calls to the bar—"

The clerk produced a slip of paper. "This just came in."

The message was from Stonewall. It read: "Important. Am on the road, will call back."

Jane crumpled the note and threw it in a trash can. "Have a drink for me, Devin. I'd best go watch the phone."

"Was that the boss?" Bundy looked suddenly alarmed. "Is that brokerage

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house thing affecting our jobs?"

"It's best you don't know who called," she said honestly, and she headed for the elevator. As to their jobs, let Devin worry a bit.

Bingo. She was going to meet Betty to play bingo, she had told Sam. Sam hated bingo; he'd never suggest coming along. And the beauty of it was, Betty actually did play bingo most Wednesday nights.

Sam still had that hurt puppy look when she left. She stopped at the fast-food place and phoned Ted, told him to meet her at the Oasis Club. The Oasis had a super band, but some male singles had started giving her the eye, and Sam wouldn't take her there anymore. She started to worry. What if Sam called Betty's house to check on her story. She pushed Betty's number, the vid-xmit off, and disguised her voice when Henry answered.

Betty had just left.

"Tell her Nancy Thompson called," Lorna said, the name plucked from thin air. "Just wanted to chat."

She drove to the bingo hall, let Betty in on what was happening. Betty promised to alibi for her, if need be. Sam might end up suspecting something, but there would be nothing concrete against her.

Outside, it had started to rain. Headed for the Oasis Club, she saw lights in her rearview mirror. They stayed with her. "Damn you, Sam!" she let out. How many years since he'd tailed her car? She'd almost forgotten how suspicious he could be. She made a quick right turn, then another, and parked on a side street for a time. No car passed by. A false alarm?

Underway again, euphoric from her incipient illicit adventure, she impulsively floored the accelerator pedal. And kept it floored. Minutes later she regretted it: a flashing red light showed behind her. "Damn!" How could she explain away being stopped *here?* Furious with herself, she slammed on the brakes. And went skidding off the blacktop.

. . . I moved unobserved onto a branching stream, then onto a side stream from that one. There were warriors and thids here, as well, but not as many. I drifted passively with the currents, looked neither to one side nor the other, but only ahead. Dimly, as would a warrior not deviant. The stream branched repeatedly; I stayed in the main channel for a time before veering onto a secondary flowage.

I came upon a hundred warriors engaged in cutting off clog from the stream sides, the clog floating away with the currents. The sight of a solitary warrior was not uncommon, and I was hopeful of passing unchallenged; but ahead, a hated inquisitor moved out from the side to block my way. I slowed, then held position as the thid's eyes illuminated me. Would the inquisitor obtrude and conjoin, probe me and find deviance? Fear started through my neurals, but mustering courage, I returned Thid's look. Though dimly. Thid inspected me cursorily, then allowed me to proceed.

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I passed another party of warriors, then entered a tiny streamlet, with gentle currents, that narrowed until I occupied half of its width. I pushed into softgrowth at the streamlet's edge, and for a time, my trailing extremities swayed rhythmically in the gentle current. Using data imprinted in my spatial lobe, I located myself: no Invaders, no Hungry nearby, and the softgrowth was robust. Excellent. No cognition-killing thid would likely show up here. I would have the isolation, the solitary contemplation that I craved.

Burrowed into the softgrowth, my thinking wandered from this subject to that. I was finding living in freedom to be a most pleasant condition, and presently I grew a bit euphoric. But then I started to feel languid, and I quickly realized why. I had consumed few shimmers on my journey from the portals, focused as I had been on evading the Master's thids; and my shimmer stomach had run empty. I could no longer catabolize food things.

I rotated about, dipped my circle-lip into the life-giving flowage, feasted on the ubiquitous shimmers. Then on the various food things I required. My hungers satisfied, I backed into the softgrowth until only my circle-lip and eyes protruded. It was at this precise moment that I set out, in earnest, to discover great truths that I felt must exist.

Had I a beginning? I filtered through memories of times past: myriad traverses of the portals, myriad times in the Labyrinth, myriad journeys down streams, great and small. A beginning? The earliest memories were blurred and faded; but there was no single, unique moment prior to which there were no memories.

As to my deviancy—I had never consciously set out to increase my capacity to think and reason. Quite the opposite. Such capacity grew naturally when, using intuition and trial-and-error to reticulate my cognition neurals, I thought long and hard on defeating a tenacious enemy. And it was while thus engaged, in a time past, that my thoughts wandered from the Invader to explore forbidden topics. The reticulation fed upon itself until I was now markedly deviant.

Was there purpose to such deviant existence? Here in this sanctuary from probing thids, I pondered the question at length, my cognition neurals reticulating and re-reticulating; and blurred glimmerings appeared of what this purpose might be. But ultimately cognition leveled out, think long and hard as I might. Dim, blurred memories returned of a time past, a journey to a strange realm, the mysterious Presence. I decided to visit this Presence. Perhaps It could somehow impart the great truths to me. Better to chance mind-death from a fearsome thid on the journey, than to live forever in a state of not knowing, not progressing.

I returned to the streamlet, moved with the slow currents. The flowage diminished further, and I had to push hard to squeeze through its narrows. Then it opened, fed onto a larger channel, and I was moving easily.

Later, in a nondescript stream, an

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inquisitor signaled me to conjoin. Pretending I did not comprehend, I moved to the edge, joined a score of warriors who battled a Hungry. The all-devouring softgrowth entity was nascent, but would grow endlessly if not destroyed. It enveloped the warrior next to me, and for a time, lasbeams seared here and there from inside the Hungry. But then Warrior's shimmer stomach ran empty and the lasbeams stopped. I had not battled this *Hungry before, but my experience base was great and my cognition was advanced: I deduced that focused attack might prevail where random lascutting had failed. So gulping shimmers and food things until both stomachs were overflowing, I fiercely penetrated the enemy. . . .*

She ended up with two wheels on the road's soft shoulder, the electric tilted sideways. *"Damn!"* From the frying pan to the fire. An officer approached the car. A large man with a hawk nose, he kept fingering his holster. Lorna opened the door and climbed out onto the blacktop. The rain had faded to a light sprinkle. She put her hands against the car and managed some tears.

The officer stopped fingering his holster. "Are you all right, ma'am?"

"I'm fine now, Officer." She sniffled, wiping away tears with her hand. "I was upset, I didn't think—"

"You could get killed, driving fast like that. The roads get slick right after a rain starts."

"I'm sorry, it won't happen again."

"I'm Officer Joe Garn. I'll need to see your driver's license and registration."

"Certainly." She opened the door, fished out her purse and produced a license. "The registration's in the glove box; I can't get to it."

Garn inspected the license. "Your name is Lorna Jacob and you live at . . ." he read off her address.

"My husband left me tonight!" she broke out sobbing. Maybe she could distract him before he noticed her age. Men were wary of you when they found out you'd been around for a while.

He looked up at her, suddenly very sympathetic. "I'm sorry to hear that. You know that you shouldn't drive when you're upset."

"I wasn't thinking right." The Moon suddenly broke through. Lorna leaned back against the electric and looked despondent. "I found a note tonight . . . he left me for a girl at the office." She managed a sniffle. "I'd always been faithful to him."

He returned the license. "You poor woman."

She ladled it on thicker. "He cleaned out our accounts. I don't know what I'm going to live on."

"That's terrible. You should get help."

"I'm afraid to. He tried to kill me once."

Garn's eyes took in the car. "Where were you going when this happened?"

"No place, really. I drove to the bingo hall, thinking it might take my mind off things. But I was going crazy sitting there, so I got in the car again and just started driving."

"I'm sorry I can't be of any real

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help— Well, look, let's get your car back on the road." He got his partner, a black man, shorter than himself. "Get in the car and ease it onto the road while we push." She did, and the electric was on hard surface again. "I'm going to let you off with a warning. You've been through enough for one night."

Mission accomplished! She put on a grateful look. "You've been very kind."

"I don't want you behind the wheel again, tonight. I'll drive you home; my partner will follow in the patrol car—"

"Huh?" Lorna was suddenly alarmed. "That won't be necessary; I feel much better now, after talking with you. I just needed someone to hear me out—"

"I insist. You shouldn't be driving after what you've been through tonight."

He opened the door for her. *Damn!* Sam would look out the window, for certain, when he heard them pull up. And what if they walked her to the door?

. . . Though my view ahead within the Hungry was murky, my spatial sense was intact. I moved to one of the firmbody globules that gave Hungry its life force, configured my lasertool for a match and started cutting. One globule destroyed, two . . . three . . . many. My shimmer stomach half empty, I nonetheless kept lascutting until Hungry's life essence had boiled away. When it was over, I made my way back out and feasted on shimmers and food things. Then I reentered the carcass and freed the dormant warrior inside. I force-filled Warrior's shimmer stomach until Warrior revived.

The inquisitor, who had seen it all, approached from behind and rotated half-around. I contemplated fleeing, contemplated attacking. But Thid would pursue forever, if need be, and the inquisitor's lasertool was tuned to disrupt warriors and scouts. How could I prevail?

Thid obtruded hard against me and we conjoined—the inquisitor's link-ridge moving into my receptacle, my link-ridge moving into the inquisitor's. Soon Thid would confirm that I was deviant, would send across energy pulses to scramble my cognition lobe. One chance—I had to deceive the inquisitor.

As the probing signals started, I remembered cognition-lobe patterns from a time of my early awareness. My neurals firing furiously, I intuited the "correct" responses to Thid's probing, and returned these to the inquisitor. Perhaps because of my actions against the Hungry, the probing was rather limited; and Thid read me to have "safe," enemy-focused cognition. More than that: the inquisitor sent strong signals to my primal lobe. Neurals in that lobe reticulated, and I was suddenly marked as a warrior to be lobe-registered and cloned. More strong signals followed by more neural reticulation: the command to return to the Master's dwelling. Playing the episode out, I moved to the stream's center, drifted with the currents, looking straight ahead, dimly. Thid's attention focused elsewhere.

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I did not wish the imposed command and the rest to be nagging at me, so I immediately set about undoing the inquisitor's work in my primal lobe. It was exceedingly difficult, but at last I succeeded.

Much later, I found myself in one of the twin great barren streams of our world, sucking in the sparse shimmers I required as opportunity arose. Approaching the Master's dwelling, an intense primal urge forced me—as it did other warriors, and scouts—to the stream's edge, where the portals would be located. My compeers entered the first vacant portals as we started to pass by. The compulsion to do likewise was strongly imprinted into my primal neurals, and when I resisted, a searing pain enveloped me. . . .

Lorna giggled uncontrollably as the patrol car made a U-turn and disappeared behind her. Officer Garn already behind the wheel of her electric, a call had come in. She couldn't believe her luck. "Oasis Club here I come," she sang.

At the Oasis, the first person she recognized was Rick, the manager. She made it a point to walk over and say hello. Rick had offered to hire her on when she'd come there with her girl friends, the week before. The night Sam was away on business. From the way Rick looked at her, as they chatted, she definitely had another admirer.

Ted had a table in a dimly-lighted corner, as far as you could get from the dance floor and the band. "I was afraid you wouldn't show," he said, smiling suavely, as she sat down.

The look in his eye said everything. A couple of drinks, a little talk, then it would be off to his place, or to a motel. Crap on that!

"How old are you, Ted?" she said when they made themselves comfortable with their drinks.

He looked at her, perplexed. "My driver's license says I'm thirty-six. Why do you ask?" He seemed to be telling the truth.

"Oh, no reason," she giggled. No man of thirty-six was going to lead *her* around by the nose. She'd be calling the shots, and she felt like kicking up her heels and having fun. She'd not exchange being cooped up with Sam for being cooped up with someone else. Not just yet.

As Ted started into his line, a rather worn one, her eyes cast about and found Rick. He waved at her, all smiles. Ted frowned when she smiled and waved back. It was going to be a fun evening, she decided. She started a mental calculation of how late she could get away with arriving home, but the image of the loaded 9 mm pistol kept popping into her head. She blocked the image out.

The band kicked into an especially lively piece. "How are your shoe soles, Ted?"

"What—"

"Let's party!" She took his hand and led him toward the dancing. Rick was taking it all in.

. . . I passed one vacant portal after the next, the pain unendurable. Desperate, I studied the patterns etched deep within my primal lobe and fo-

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cused energy onto one of the offending hard neural-connections. Nothing happened, so I tripled the impinging energy and sharpened the focus. The connection presently broke. Another connection and another, then ten in quick succession. I sharpened the focus even further, and presently many hard neural-connections had opened. The pain eased. I set about undoing other primal compulsions, and by where the portals ended, I had broken almost every hard connection in that lobe. I felt suddenly free of the Master's oppression, and for a time I was euphoric.

The great barren streams came together in a sea. A brief time of tranquility and I was into a first turbulence, another stream, and finally the Labyrinth, where shimmers appeared spontaneously and in great numbers. Feasting until my shimmer stomach was full, I drifted with the now gentle current, traversed the Labyrinth randomly. I felt as one with our world.

From the Labyrinth, another great stream, a second sea, a second and even greater turbulence. Then into an immense, surging flowage, the mightiest one in all our world. I pushed cross-current and moved onto a great branching stream.

In the realm of the Presence, I let the currents take me where they would. Down endless branches and subbranches. I found myself in a tiny streamlet. Moving to the edge, I encountered unyielding lifegrowth. A sort of barrier.

Pressing my back against the barrier, the fluids washing past, I tingled from great energies emanating from somewhere behind. Not the even, rhythmic pressure energies of streams flowing, but violent, erratic energies.

Erratic, yet resonant with weaker energies flowing through neurals in my cognition lobe. Erratic, and yet not erratic. Complex. Patterns, and patterns within patterns. I was close by the wondrous Presence that I had sensed long ago, and my neurals quivered resonantly as the energies from behind pulsed, and then pulsed again. I drifted, my back still against the streamlet edge, until I reached a place where the energies felt exceedingly close by. Then I lascut through the hard-lifegrowth barrier, felt the wondrous Presence even more strongly.

Farther in I cut, until the resonance turned to pain—and joy. And the pain and the joy became unbearable, exquisite. The Presence was now close by indeed, and that Presence was clearly sapient—there could be no doubt of it. I contemplated cutting in even farther, physically joining to the Presence; but I sensed that my neural lobes would literally disrupt if I did. So I held my position, lived in ecstacy and searing pain for what seemed an eternity, but was only a moment—my cognition-lobe neurals reticulating and re-reticulating at a geometrically increasing rate. Until suddenly, without warning, my shimmer stomach ran empty.

In a panic, I turned and started out. My movements grew weak, my thinking, my spatial presence murky. Almost dormant when I reached the streamlet, I feebly tried to suck in the nearest shimmer. And failed. Cogni-

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tion and awareness faded as I sucked again at the shimmer, and this time ingested it. A second shimmer and a third, as I fought the eternal sleep. Cognition finally returned, and I started to feel strong. I feasted on shimmers, and then on food things until both stomachs were full.

Drifting. Pain . . . joy . . . the sapient Presence . . . the purpose of my existence—I pondered these things and cognition neurals once more began to interweave. Slowly, steadily this time. The Presence . . . ? It was no simple entity—like warrior, scout or thid, or even Master. The Presence was here, there and everywhere within this realm.

Have I been put here in this world to do the work of this Presence? *the question suddenly formed. The prospect was exhilarating, and I found myself wanting fervently to believe.*

I contemplated the matter long and hard, but found no certain answer. It occurred to me that if I had a second being to commune with—a being like myself, but with wholly different cognition; then together, we might better gain the understanding I sought. Leaving the realm of the sapient Presence, a plan took shape.

Near the site of my prior solitary existence, I waited and watched. Ultimately a scout, looking for signs of enemy or signs of trouble in the softgrowth, came into view. And spied me. Scouts cannot lascut, so I was safe from immediate harm. The danger was should the scout escape me and report my presence to the Master, inquisitors would be sent.

Scout paused to register that I was deviant, then continued downstream. I moved in from behind, within Scout's blind area. As Scout resumed scanning the streamlet's sides for signs of trouble, I pushed quickly forward, rotated a half-turn, and conjoined hard—my link-ridge penetrating Scout's receptacle, Scout's link-ridge penetrating mine. Scout, perhaps presuming me to be an inquisitor, went immobile, and we drifted downstream as one. Probing deeply, I found Scout's neural makeup to be identical to mine, even though Scout's cognition lobe was less abundantly reticulated.

My probing completed, I sent focused energy pulses into Scout's primal lobe, breaking the hard neural connections that compelled Scout to obey thid and Master. I contemplated reworking Scout's cognition neurals, then decided not to. With power must come restraint, I reasoned. I would not follow the Master's ways. I wished Scout to be Scout, not a cognition-lobe clone of myself.

Follow me, *I requested, just before we disjoined, and I pushed into the softgrowth, Scout close behind me. What ensued, as we shared one another's experiences and insights, was the most beautiful time of my existence. I revealed to Scout my strange odyssey in the realm of the Presence, and I imparted to Scout the searing pain and exquisite joy I had felt. We pondered the nature of the Presence and the purpose of existence. Separated, we would independently contemplate these things, and this contemplation would lend freshness to*

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our next sharing. My neurals reticulated rapidly during this time of happiness. As did Scout's. Though still, the great truths stayed constantly beyond us.

Did the sapient Presence oversee our vast world? Had we been put here only to serve It? And if so, did Master and thid also serve? Or were they, as Scout intuited, wicked intruders into our world? We had no clear answers, but the array of possibilities dazzled us.

I vividly remember the exact moment when—as we reposed, deep in the softgrowth—Scout asked the question that would change our lives forever. Warrior, *Scout started out,* I would never willingly live again in dim cognition and enslavement to the Master. So I grieve that our compeers must exist in this way. Why could not they be set free, as was I?

Indeed, why not? *I agreed. The prospect of extending our communing to a host of our compeers fascinated me, and my cognition neurals reticulated rapidly as we worked out a plan. . . .*

Midnight. She had left Ted and Rick arguing, outside in the alley, about Rick paying her so much attention. What a night! She hadn't had so much fun in years. But now, driving the dark streets, her mind turned to explanations for Sam, and the exhilaration faded. It turned to apprehension the last slow block home. *Why didn't I unload the pistol?* she chided herself as the car eased into the driveway. Every light in the house was on. She clicked the remote and the garage door raised.

Sam's car was gone. She was trembling just a bit as she walked into the kitchen. A note on the table: "Lorna, I called the police and the hospitals, then went out looking for you."

Lorna scratched her chin. Where would he go looking? To Betty's house for sure. And possibly the Oasis. She was lucky she'd left when she did.

He hadn't written a time on the note; he could be back any moment. She checked the nightstand drawer; the pistol was missing. Moving quickly, she undressed and scrubbed off the remnants of the perfume and makeup, got into her pajamas—the long, blue cotton ones—and climbed into bed. Her stomach felt queasy, she could hear her heart beating.

It beat louder when the garage door opened and the car pulled inside. She thought of their early years together, and she was afraid. The shooting incident: she had pulled into the driveway at 5 A.M., Sam out of town. Except Sam had been there waiting for her. Five bullet holes in the car—how could they have all missed her?

She still didn't have a story . . . she'd have to improvise one. She was *always* improvising, it seemed. Was it the pressure or the danger she liked—

The light came on and Sam was standing there looking at her. His face was flushed, his eyes had a nasty look and there was a bulge in his coat pocket. "Where were you, Lorna?" he said quietly.

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Lorna's mind churned.

"Where were you?" he repeated.

She got out of bed and walked to the kitchen, Sam on her heels. She steeled herself. "I didn't stay for bingo—"

"I *know* that!" he rasped. "I just came from Henry and Betty's house. After I explained you were still missing, Betty admitted that you left right away. Where did you go?"

"Don't you trust me, Sam?"

"Where were you, Lorna?"

"I don't know if I should tell you, if you're not going to believe me anyway." Sam looked ready to explode. "Well, I might as well let you in on it. Sam, I went out and . . . got a job."

"A job! Doing what?"

"You want to know what?"

"Yes. A job doing what?"

Lorna's brain was spinning. "Thank you for not trusting me." She flashed Sam a hurt look, but he didn't respond. "OK, I'll tell you. I got a job at, uh—" inspiration struck "—the *Oasis Club*."

"The Oasis Club?" Sam blurted. "When?"

"Tonight. What's the big deal? You were in favor of me working—"

"Yes, but not at a place like that. You've got a good education. You should get a respectable job."

Sam seemed to be calmer now. "You're always putting me down!" she let herself explode. "Nothing I do is good enough for you!" She managed some tears. "I wanted to contribute. I was going to tell you about it first—but I knew you'd get angry and accusing." She looked away, almost lost it giggling while making sobbing noises.

"Lorna, I'm sorry," he said. "I'll call the Oasis and tell them you won't be back—"

"Huh?"

"I'll tell them you won't be coming back. It wouldn't work out, Lorna. You should get yourself a *real* job." His eyes narrowed a bit. "Is it all right if I call them?"

She put her arms around him and managed a soft sob. "Sure it is, darling. If you'd rather embarrass me on the phone than come to bed with me, then go right ahead—"

The doorbell rang. "Who the hell is it this time of night?" Sam said testily. It was Officer Garn.

. . . We searched and found a Hungry. It was tentacled about a hundred small streams, ravenously consuming the shimmers and food things that these streams brought to it.

Hungry growth everywhere, we came upon three hundred engaged warriors. I refrained from looking about, as the illumination from my looking would surely alert inquisitors. Instead, I eased in behind the first warrior I came abreast of. Warrior was occupied lascutting into Hungry when I obtruded and conjoined. Innately aggressive, Warrior thrashed about, tried to pull free. But when I signaled I was an inquisitor, the compulsions took force, and Warrior became tranquil. As I had done with Scout, I purged the dreadful compulsions from Warrior's primal lobe; and I imparted to Warrior the essence of who I was, and what it could mean to be free. Also, I gave

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to Warrior an understanding of the sapient Presence. Beyond that, I worked Warrior's neurals no further. As with Scout, I wished Warrior to be Warrior.

Finished, I pulled free; and then I moved to the next warrior and did the same thing. The first warrior, cognition potential now unleashed, observed carefully, and then moved alongside me to a third warrior and a fourth. We liberated these compeers, also. One each—the process was expanding at a geometric rate.

Suddenly an inquisitor was moving hard upstream to intercept me. When I did not rotate the half-turn to conjoin, Thid's lasertool extended. Desperate, I feinted to one side, then went to the other as a lasbeam seared past where I had been. Behind Thid now, and abandoning caution, I obtruded hard and conjoined. Thid sent out powerful energy pulses intended to scramble my neurals. But with great effort, my stores of shimmers and food things drawing down rapidly, I dispersed the pulses along myriad unintended paths, where they were too weak to have effect. Then I sent out powerful, well focused pulses of my own, from massed neurals acting in tandem. Thid resisted briefly, then became tranquil.

I began to probe. Thid's cognition lobe held just as many neurals as mine, or Scout's. But the neurals were of a hard-connected type; and though Thid had limited cognition potential, the inquisitor was thought-slave to the Master. It made sense. Scouts and warriors observed in minute detail, devised ways to overcome a tenacious enemy. This required an adaptable cognition. By contrast, inquisitors marked warriors for cognition-lobe cloning, identified deviant warriors and scouts, scrambled neural lobes here and there. Hard-connected obedience to the Master would take precedence over thought and reason.

With great difficulty, I broke Thid's hard neural connections, one by one. Then, as best I could, I filled the inquisitor's cognition lobe with the same thinking and concepts I had imparted to the warriors. Because of Thid's neural makeup, I was uncertain as to how well I had succeeded; and I was surprised when Thid stayed abreast of Scout and me as we liberated other warriors along the stream.

The liberating finally over, we all mingled for a time. I conjoined with a succession of the newly-emancipated warriors, and they, in turn, conjoined with many more. My proposal spread that we dwell together as a group, pool our neurals in a grand search for enlightenment. The plan was accepted by all.

A solitary scout appeared and scrutinized us closely. A warrior moved in from behind, and we freed yet another compeer. Then I took the lead, and our group pushed hard upstream, voraciously gulping shimmers and food things as we fought the currents. Past one branch, then a second and a third, to a larger, swifter stream. And then we drifted with the currents, put distance between ourselves and the Hungry, and ultimately arrived in a region of robust softgrowth. Communing with one another, we agreed

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that this region would be our homeland, and we settled in. . . .

Officer Garn introduced himself, and stepping inside, turned to Lorna. "The lights were on; and after all that you've been through, I wanted to make sure you arrived home OK. Is this—?"

"This is my husband, Sam," Lorna said evenly. Her heart was pounding.

Joe Garn looked dismayed. "I thought—well, apparently things have worked themselves out. I'm glad to see you're OK."

"What happened?" Sam asked, bewildered.

"It's nothing, darling," Lorna said. "I'll explain it to you later." Her eyes signaled Garn to leave. "Thank you for your concern, Officer. As you can see, I'm just fine now—"

"Well, OK." He looked Sam over, suspicious, then his eyes fixed on Lorna again. "If you're really sure."

"Yes, we're both fine."

"Don't hesitate to call in if there's trouble."

"What is this all about, Officer?" Sam demanded.

"I'll explain later," Lorna interposed. She opened the door for Garn to leave.

Stepping outside, Garn glared at Sam. "I'll be leaving now. But if anything happens to her, you'll regret it." Lorna quickly closed the door behind him.

"What the hell was *that* all about?" Sam erupted.

Lorna studied her nails. "Nothing all that much, really. On my way to the Oasis, to get that job, the roads were wet and the car skidded. The officer and his partner were kind enough to push it back onto the road."

"It sounded a *lot* more serious than that—"

"I was very nearly killed. Is that serious enough for you?"

"Lorna, I am certain he was not talking about a skidding incident."

"Well, you may be right. After it happened I said a few things—I was pretty shaken. I mentioned that I was going after that job, and that you might very well get totally out of control when you found out. Remember when you lost it, and shot the car out from around me? For no reason at all—"

"Lorna, that was a long time ago. I've changed."

"How do I *know* that? You're young again with all those hormones. How do I know what you might or might not do?" She managed to cry, he comforted her, and she cried spontaneously for a time. He slipped the 9 mm pistol back into the nightstand drawer while she pretended not to be looking, and shortly thereafter they ended up in bed. Their sex drives had come back strong from the implant and the nanomeds.

Lorna stayed in bed until she heard Sam's steady snoring, then went to the kitchen, to the phone. Sam would be calling the Oasis the next day; she had to talk to Rick. The phone kept ringing. She looked at the clock: the club had closed. Sam would be calling early and often from work. What if he got hold of Rick before she did?

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She'd heard someone use Rick's last name; it started with an "M." She tried hard to remember and finally the name "Martin" popped into her head. Rick Martin. She opened the phone book and started punching numbers.

Jane awoke from the ringing to find Max Stonewall on the line, the vid on. "Sorry for calling at this hour—"

"It's OK." She rubbed her eyes and yawned.

"I talked with the wife and with some other people in Gunnison, Jane. The situation is interesting."

"Yes, go on." Max's "interesting" sometimes had grim connotations.

"The hunter we talked about—my guess is he died from injuries, after all—"

"You found medical indications?"

Stonewall scratched his head. "Not really. But they found him seven miles down canyon from his van. He had run off the road up above, and it seems logical he might have been hurt."

"What is the wife saying to that?"

"She won't budge in her thinking. But Jane, this will blow your mind—there was a second person, an Arnold Green, who's a candidate. They found him high up in the Wasatch inside a camper, along the same jeep trail the younger guy had been on. His cadaver was a mess, but there was no indication of an accident. His age was 102 when they implanted him—how's that for fitting the profile?"

"It'll do. What do you think happened?"

Max shrugged with his eyebrows, a gesture he reserved for the vidphone. "Can't say, for certain. Asking around, it appears the two men didn't know each other. I think the younger guy came across a sick or injured Arnold Green, panicked, and had the accident with the van. Probably hemorrhaged trying to hike out—it's a long haul on foot.

"If a runaway event happened at all, it should logically have happened with Green. Think of how many nanos must have been active in restoring a man that age. The implant and the control nanos could have been hard pressed to keep up, and the implant might have regressed to lower-order programming." He picked at his chin. "Still, Jane, that leaves the time factor. I can imagine Green taking sick or a cancer starting up, particularly given Green's chronological age. But he would have had plenty of time to drive back to town, to a hospital."

"Well then maybe an accident did kill him, after all. Can you suggest anything specific to nail it down?"

"Yes. Arnold Green was buried in a closed casket, and I've talked to his family about exhuming the body. What I had in mind was taking a sample and separating out a few of our little neurocomputer nanos to examine in detail."

Jane reflected on it. "Good idea. Now—how do I do all that and keep James from getting wind of it?"

"That's a damn good question. Maybe you should go to him and tell him what we've found out."

"I don't see I have a choice—"

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"No, better yet, *I'll* tell him. He hasn't any leverage over me, and I can hint around about going public if I'm not satisfied. But you'll have to take it from there." He shook his head and grimaced. "James could fire you on the spot, once he figures out we're in cahoots on this thing. How about it, Jane? Willing to risk it?"

She swallowed hard. "Go ahead and talk to James."

"Are you sure?"

"Just do it, Max."

No luck in reaching Rick, probably he had an unlisted number.

Still sitting near the kitchen phone, Lorna looked back over the years. When she had started to age, when men had stopped looking at her—Sam had been good for her then. All in all, they had had a good life. But now . . . did he expect her to totally waste her new youth? She contemplated her prospects. With the kind of "bod" she was getting, she could make a name for herself modeling. But she had to meet people, get connected. She pictured herself at the big fashion shows. *Why not?* she thought.

Sam came yawning out of the bedroom in his pajamas. "Can't you sleep, darling?" he said tenderly.

She gritted her teeth. "Sam, I've decided to keep that job at the Oasis."

. . . In our homeland, a time of great enlightenment ensued, as warriors and scouts alike, we neural-linked endlessly. I remembered well what it had been like to be cognitive and alone, and I savored the varied perspectives and new insights the communions provided.

Names came into being, and Scout became Scoutkn. Thid became Thidkog. Thidkog, always at my side, seldom joined in the communing; for the former-inquisitor's cognition neurals, being mostly hard-connected, could not keep pace. Trying to compensate, I would periodically impart to Thidkog the essence of the best new thinking. Thidkog was grateful I made the effort.

After a time, we started searching out warriors nearby in the region, which warriors we liberated to live as the Presence might see fit. We freed additional scouts, as well. Our numbers swelled. . . .

Sam was pacing the floor. "I just can't understand why you'd want to work at a place like that." More pacing. Lorna entered the bathroom, studied herself in the mirrors. Firm, well-muscled flesh, not a blemish or a wrinkle anywhere: she could do well for herself, modeling. In the kitchen again, Sam was sitting at the table, looking dejected. Finally he said, resignedly: "If that's what you really want, Lorna, I guess it'd be OK for a while."

She pulled him to his feet and hugged him tightly. "It won't be so bad, darling," she said in her most affectionate voice. "And it will make me very happy." Releasing him, she made her face loving and grateful. Surprisingly, that was exactly the way she felt. "I'm tired, darling. Let's go back to sleep."

Lying in bed, she wondered why

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she'd been so worried. The years had mellowed Sam, and even his new young body and all the hormones that body produced, hadn't altered the fact. It was a thing of the mind. The Sam of old had sprayed the car with bullets. This one had asked where she had been, had heard her out, had even been willing to let her work at the Oasis. Feeling suddenly very content, she sighed, snuggled against her husband and fell asleep.

Sinister visions appeared.

. . . Numbering a thousand, we could no longer regularly commune with each and every compeer; though for a time, we made the effort. That logistical fact was not greatly limiting. The communal network acted as a filter: the insightful and interesting were passed along, one warrior or scout to the next; the mundane was discarded. And there was a compounding effect from our sheer numbers in the enlightenment of each one of us. How wonderful it would be, some of us started to express, if our community were not a mere thousand emancipated compeers, but perhaps ten or a hundred times that number.

Thus came about the first massive liberation, the first great crusade.

A full two hundred of us, Scoutkn and Thidkog at my side, set out from our homeland. Traveling the barren flowages, we ingested shimmers as we could; and after a long journey, we reached the first portals at the dwelling of the Master. Communing at the edge of the great stream, I informed my compeers of a wild action that I planned. Euphoric from the grandeur of our mission, I intended to liberate the Master. From what, I did not know.

While my compeers waited, attached at the stream's edge, I moved to the nearest unoccupied portal, entered it, and conjoined hard—my link-ridge penetrating the Master, and the Master's link-ridge penetrating me. The result was near fatal.

The Master probed and I returned the responses of a non-deviant warrior. Then I let loose with my surprise: with all the power I could focus, I started probing the Master's neural lobes. Or tried to. I read nothing; it was like probing streamside softgrowth. But the Master understood only too well the nature of my act. I felt searing, pulsating energies that would have scrambled every neural in my lobes, whatever I did to diffuse these energies. So I instantly pulled free. Chastened, I rejoined my compeers and we continued the odyssey.

In the Labyrinth, we feasted on shimmers. Then, in the name of the Presence, we commenced liberating every warrior and scout we came upon. By the second turbulence, we numbered in the thousands; and we continued the crusade on the journey back to our homeland. When we arrived, some twenty-thousand strong, I looked ahead to a glorious future.

We extended our homeland in all directions and settled in. . . .

She was old and bent, and age spots covered her hands and face. They

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were back at the Nanomedic labs, she and Sam; but this time there were no smiles, no happy talk. Max Stonewall, still young-looking with piercing blue eyes, told her grimly: "We're all very sorry it didn't work out." Sam, still in the bloom of his second youth, was careful not to touch her.

"Hold me, Sam!" she screamed at him.

The dream faded.

Lorna, in a panic, rushed to the west window and studied her hands in the shafts of moonlight.

It was the wee hours when the vidphone rang. Taking a deep breath, Jane pressed a button and saw the face of Thorton James, CEO of Nanomedic Corporation, her boss three levels removed. He was livid. "Jane—did you know Stonewall was over in Utah stirring things up?"

She positioned herself and pressed the vid-xmit button. If James came on the phone visual, you did the same, no matter the hour. "Yes, he phoned me earlier."

Unblinking cobra eyes seemed to fix on her. "Did you know ahead of time that Stonewall was going to Utah?"

Max wouldn't have implicated her. He wouldn't have lied, he just wouldn't have given James names. So she could tough it out, had intended to tough it out. But what about her credibility down the road? "Yes," she heard herself say. "I told him about the Utah incident. It was something that had to be checked out, and he was going to be in the area anyway—"

"Jane, damn it! Stonewall isn't your boss anymore. He isn't anyone's boss. Haven't my memos on letting Legal handle these things been clear enough for you?"

"Yes sir," she said. "But I got a call from a woman in Utah who was convinced there had been a system failure—"

"Damn it, Jane, you should have referred her to Legal. Stonewall has really churned things up; it may already be too late for damage control. Lawyers could be coming out of the woodwork at us."

"I guess they could," she admitted. "But still, we have to follow up on what Max found out."

"Jane, you're still screwed up. Whatever may or may not have happened over in Utah is none of your business. We have people who spend their time dealing with that sort of thing—"

"Lawyers?"

"Yes, experienced legal people. You've really opened a can of worms. Stonewall is making noises about going to the media if we don't resolve this thing. Did you also know that?"

"I—uh—"

"Jane, there's a 9 A.M. flight from where you are to here. I want you on it."

"But we have appointments tomorrow," she said, swallowing hard.

"Frankly, Jane, I don't want *you* out in the field representing Nanomedic. Devin can handle the visits. When you get in, come straight to my office. Is that clear enough?"

"Yes, sir." There was a click and the vid went blank. *Goodbye job*, she

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thought to herself.

In the moonlight, the flesh was still youthful, unblemished. "What a shitty, stinking dream!" Lorna muttered. Her thoughts wandered ahead. Tomorrow would be a big day, she'd make it one. She'd start out with a good workout, clear out her mind. Then she'd locate Rick and get on the payroll at the Oasis. Rick might know people who could put her onto some modeling work. She yawned. Right now, she needed that beauty rest.

Returning to bed, she had the feeling, the premonition, that all was not well. She couldn't shake it. She snuggled closer to Sam, hoping it would drive the foreboding away. It helped. A vague deep itch in her left thigh; she absently scratched at it. The itch persisted, sharpened. For a time, sleep eluded her.

. . . The density of shimmers in the streams proved inadequate for our needs. To remedy this, we borrowed from the methods of the Hungry and stimulated certain softbody entities, causing the streams feeding our homeland to proliferate and enlarge. We continued the process until there were sufficient shimmers to sustain us all. But not, it sadly turned out, to sustain the softgrowth.

Even as we mingled and communed, and gained insights, the softgrowth of our homeland started to wither. Softbody soldiers appeared, and a few of these fighters attacked us—that had never happened before. Scouts arrived in large numbers. We liberated most of them; but some passed through our homeland unchallenged, and presently thids and warriors by the tens of thousands appeared. We liberated the warriors as they removed dying softgrowth, liberated the thids, also. The added shimmers our swollen numbers now consumed further deprived softgrowth in our homeland, much of which softgrowth died. More scouts, and more warriors and thids—it was a fatal cycle.

A time came when Scoutkn, Thidkog and I could stay no longer in the death rot, and we departed, seeking a new homeland. . . .

Awake again, from a dreamless sleep this time. A sharp pain where the vague itch had been. She had torn a muscle, maybe, working out or dancing. She waited for the implant to take care of it. Sam was lying on his back, softly snoring. She tried to sleep, too, but the pain steadily grew worse. Why wasn't the implant fixing the problem? She rubbed at her leg, the pain was excruciating.

"Sam—something's wrong!" she cried. Sam awoke with a start.

Jane Hammer arrived at the airport a half hour before flight time. Sometime just before dawn, she'd decided her job might be salvageable, after all. James logically wouldn't want both her and Max threatening to go public. But he'd damn well make life miserable for her at Nanomedic. Did she really want to stay under those conditions?

At the counter, the agent looked at her ticket, then at a note, and said:

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"You've been diverted, Ms. Hammer."

"I've been *what?*"

"A doctor called in and arranged it, and left a message for you. Here." She handed the note to Hammer.

It turned out to be rather cryptic. "Jane," it read, "I have an extreme medical emergency at the hospital in your area of expertise. Tracked you via your company secretaries and Devin, and have taken the liberty to ticket you through to this city. Don't fail me." It was signed "Zugart."

"Must be important," the agent said, curious.

"It is." Zugart had carefully avoided the mention of implant systems or Nanomedic, and Jane wasn't about to do so.

"You didn't know about it?" the agent persisted.

"Hardly." She considered Thorton James's reaction if she didn't show up at Nanomedic. She'd be out on the streets for certain. It would be a matter of face: James could allow *no one* to flagrantly and directly disobey him, whatever the reason. She took a deep breath and slowly let it out. "To hell with James!"

"What—"

"That means I'm diverting."

"You'll have to hurry, then, Ms. Hammer. Boarding started five minutes ago."

The agent told her the concourse and gate, handed her a boarding pass, and she took off running with her carry-ons.

"Please sit down, Mr. Jacob," Doctor Zugart said. "I have the scan results for your wife." A good two hours before his usual morning rounds at the nearby Angel of Boundless Compassion hospital, Zugart had been called in to look at Lorna Jacob. Now back at his office, his receptionist was busy canceling appointments.

"Will she be OK?" Sam Jacob asked Zugart apprehensively.

"I've no reason to think she won't be, given proper treatment. But right now . . . well, we have a rather puzzling anomaly."

Sam's smile vanished. "An anomaly? I don't understand."

"I assure you, Mr. Jacob, we'll sort it out. . . ."

"Doctor, what's wrong?"

Zugart pushed a pad, the lights dimmed and the wall to their side illuminated. He spoke a patient number at the desk-mike and a 3-D scan-image of Lorna Jacob appeared, life-size, on the wall. More words, followed by a zoom-in to Lorna's upper left leg. They saw a diffused red strip about two centimeters long and a half centimeter across. "The affected region is in the quadriceps muscle," Zugart explained. Still using voice control, he rotated the image. "The red color indicates infection and dead tissue—"

"She thought she tore a muscle working out," Sam Jacob said, dismayed.

"I'm afraid it's more serious than that."

"Isn't the Nanomedic system supposed to prevent infection?"

"Absolutely. Cancer, infection or disease—it corrects a problem while it's still incipient." Zugart scratched at his chin. "The scans were taken an

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hour ago, right after your wife was admitted. They're routine. I was as surprised as you are right now when I saw that red area. Apparently the Nanomedic system has malfunctioned."

Sam was taken aback. "The Nanomedic sys—"

"We'll have to keep Lorna here a while for treatment. Right now, we're giving her massive antibiotics. Thank God a few companies still make them for Third World markets," he added.

Sam nodded.

"I don't want you to worry unduly, Mr. Jacob. The problem appears to be confined to a region in the quadriceps, and an expert from Nanomedic is expected here shortly. Since virtually everyone these days carries a Nanomedic implant, you can be certain the company will get to the bottom of this right away. At no cost to you, it goes without saying."

"Thank you, Doctor."

"Let's see now . . . what is Lorna's age?" From the sudden apprehension on Sam Jacob's face, Zugart immediately regretted asking. He should have looked it up in the file.

"Lorna will be a hundred this month," Sam responded. "Is that important?"

"No, not really," Doctor Zugart said pleasantly. He smiled reassuringly, walked Sam to the door and shook his hand. At his desk, again, he tried to think back. Somewhere in some journal, he'd read speculations about implant systems and age.

Lorna raised her gown, and touched the skin near the sore area on her leg. "Ow!" she let out, getting too close. She ended up crying. All that beautiful muscle she'd put on. For what? So it could rot away? She looked anxiously at the doorway. Where the devil was Sam?

. . . Well distant from our dying homeland, we started to see small numbers of unliberated warriors, here and there. The numbers gradually increased.

It was at this point in our journey that loyal Thidkog saved my life. I should have been more alert to danger, but I was studying the soft-growth, lost in thought, when suddenly an inquisitor blocked my way. Thid's lasbeam burned in close to my eyes, and I waited to erupt. But then loyal Thidkog was out in front, too. Fiercely lascutting my attacker. The inquisitor, not neuralled to deal with a deviant thid, went rigid. Loyal Thidkog moved around behind, obtruded hard and conjoined. The inquisitor jerked twice, then became tranquil as the conversion ran its course. It was Thidkog's first emancipation.

Acting on impulse, I liberated several nearby warriors, and some of these warriors liberated additional compeers. When we resumed our journey—Scoutkn, Thidkog and I—a hundred of the liberated moved alongside us. And from time to time, we added to our group, until presently we numbered a thousand. We settled in a region of robust soft-growth, and started new lives in a new homeland.

I had no wish to see our new homeland die. The problem before had

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been overpopulation, so in the communing I urged that we reject thought of any future crusade. Many of the liberated will follow us back to our new homeland, *I argued,* and our numbers will overwhelm the softgrowth.

Most in our new homeland agreed with me, but some opposed me for reasons of fairness. Our compeers deserve the chance to live in freedom, too, *a warrior asserted bluntly as we communed. From a pure-fairness perspective, the warrior was right. But that fact would not save our homeland.*

It was with mixed sadness and joy, then, that I watched our numbers grow. Crusaders, none of whom had lived through the dying and the rot of the old homeland, would go out and return with thousands of newly-liberated warriors. How could I fault these crusaders?—they did only what they believed to be right. Yet I knew what must inevitably follow.

And follow it did. We extended our homeland in an effort to accommodate the growing population, and we stimulated the softgrowth entities to augment the network of shimmer-carrying streams. Sadly, our numbers increased more rapidly than we expected, and it was presently apparent why. Of the myriad liberated warriors, scouts and thids arriving, only a portion had been freed by crusaders from our *homeland. There were other homelands and other crusaders, we learned.*

By then, the source streams that nourished us were carrying in less shimmers, and were clogged with wastes. Even far upstream. Panic ensued, and our compatriots vacated the region by the thousands. Scoutkn, loyal Thidkog, and I prepared to do the same.

But what if there is no place to go? *Scoutkn worried to me, just before we left.* What if it is like this everywhere? *I could find no honest words of cheer, for I had the same dire foreboding as my dear companion.*

The three of us—gentle Scoutkn, loyal Thidkog and I—filled our stomachs and set out. A short distance along, the streamlet we traveled became hopelessly clogged with dead softbody things; so we pushed laterally through the softgrowth, toward a nearby large flowage. The growth was dying and rotting in large patches, so little lascutting was needed. We encountered few shimmers, but the stores in our stomachs sustained us, and presently we neared the flowage. I was only partly prepared for what we saw there. . . .

Sam had come back, but could do nothing to help her. Lorna was hurting all over, now, and her heart wouldn't stop pounding. She'd heard the nurses whisper about the implant going bad. What a shitty break—just as she was getting everything together. She heard someone breathing hard, and suddenly realized it was herself. "Damn it!" she let out. "Sam, what's happening to me?"

"The doctor will get you well," Sam tried to comfort her.

"If you love me, Sam, make them do something for me."

* * *

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Jane Hammer looked grim. "This really worries me. Even given Lorna Jacob's chronological age, the tissue shouldn't—I once met her, by the way. I feel terrible this is happening to her. . . ."

Doctor Zugart look perplexed.

"She and her husband toured the research labs the month I started with Nanomedic. The first group of elderly persons implanted: it was a big media thing. Anyway, as I started to say, the tissue shouldn't be degenerating like that. System failure or not. And in patches?" She pointed from one red area to the next on the latest 3-D scan-image of Lorna. There were many such areas.

"Regardless, I have to do *something*," Zugart said. Jane had arrived at the hospital by cab, a half hour before.

"I assume you have implants in stock?"

Zugart nodded. "Implants and additional units of nanocharge."

"If Lorna's implant has cratered, and *that* situation is somehow causing the problem, it can be switched out—"

"The hospital has an installation program on line, of course," Zugart said. "But as for exchanging one implant for another, well . . ."

"I can link-up to Research from here and create a program module for that." Jane patted her briefcase.

"Good."

"But a switch-out may not do it. Particularly after looking at the scans, I'm not optimistic. I'm worried that the nanomeds might be the problem."

"Has that happened before?" Zugart asked.

She reflected on the Utah incident. "We don't know for certain," she said honestly.

"Could the nanomeds be OK, and could Lorna have developed some degenerative condition the nanomeds weren't designed to cope with? Her chronological age being what it is."

Jane shook her head. "The H-M nanomeds are pretty potent. Despite the architecture being at the atomic level, each one of them is a full-blown neurocomputer, with sufficient neurals—by a large factor—to overcome anything that might come along. It's hard to imagine Lorna developing a condition that the nanos couldn't cope with. *If* they are functioning properly—"

"I understand," Zugart said. "So then, do we switch out the implant or the nanomeds or both?"

"We have no way to extract a charge of nanomeds. Lorna would have to be bled totally, and even that wouldn't work, because the nanos are programmed to avoid regions of blood discharge."

"Suppose we give Lorna a second charge, regardless," Zugart asked. "What would that do for her, or to her?"

"The old nanos, if defective, might simply use up some oxygen and dump some carbon dioxide into her blood—that's the *best* case scenario." She grimaced. "On the other hand, the old nanos could thoroughly contaminate the new ones, making things that much the worse for her. In truth,

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the subject hasn't been researched."

Zugart was discouraged. "What do you recommend, Jane?"

"I say, go ahead and switch out the implant. I don't hold out much hope, but if it works, wonderful. If it doesn't, you might indeed then run a new charge of nanos through the IVs. But only as a last resort."

Zugart thought about it. "OK, we'll switch out the implant and then take it from there. I'll schedule Lorna for robosurgery. In, say—" he looked at his watch "—a half hour from now, if you can have that switch-out module ready."

"It will be ready, Doctor."

"Good." He stood up to leave. "Stick around a while, if you can, Jane. I may need to pick your brains further."

"I have no better place to go," she said, thinking of her ruined career at Nanomedic Corporation.

The hospital bed was cranked down almost horizontal, and Lorna was lying on her back with her eyes closed, perspiring and breathing hard, as Doctor Zugart entered the intensive-care area. The IV tubes still put nourishment and antibiotics into her arm. Nurse Jepson had a hand on Lorna's forehead and Sam was quietly holding his wife's hand.

"She has a fever—103° a few minutes ago," Nurse Jepson said. "It seems to be getting worse."

"Do something to help her, Doctor," Sam said, fear in his eyes for the first time. "We've been together almost sixty years. I don't know what I'll do if I lose her."

Zugart forced a smile. "There's a problem with the Nanomedic system, but we're working hard to correct it, Mr. Jacob." His voice was carefully upbeat. "I'll need your signature on a few papers." He handed Sam the sheets and a pen.

His hand shaking, Jacob signed on the lines Zugart had marked. "What are you going to do, Doctor?"

Zugart told him what he had in mind. "She'll be getting the best of care," he added.

Sam nodded.

Two dark-haired men in white coats showed up, pushing a gurney. "If you'll stand aside, Mr. Jacob, we'll get her ready," Zugart said.

Nurse Jepson transferred the IVs while the men in white coats slid Lorna onto the gurney. "You can walk down to R O R with her," Zugart told Jacob, and the men started wheeling Lorna away. In the corridor, Jacob took his wife's hand again as the gurney rolled toward the elevator. She was breathing heavily. "The robosurgeons will do the actual replacing," Zugart said. "But I'll stay with your wife the whole time."

Lorna's green eyes opened and fixed vacantly on her husband, who patted her hand. "You'll come through this fine," he whispered. Lorna coughed twice, and Zugart saw flecks of blood mixed with coughed-up phlegm and spittle. He made eye contact with Nurse Jepson, who promptly daubed Lorna's mouth with a nearby edge of the gown.

What shitty rotten luck... the words kept rolling through Lorna's

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head. Sam was looking down at her, lovingly, his face full of grief. She was helpless and immobile again. Like before the implant, only worse. She watched the corridor lights pass slowly overhead; then her vision fogged. For the first time in a long, long time, she contemplated death.

. . . What we saw at the stream greatly disheartened us. The softgrowth was dead and rotted approaching the flowage. And cutting through hard lifegrowth at the edge, we saw that the stream had been fouled: dead and decomposing softbody things floated everywhere in the currents. The various soft food things were still abundant, but the life-giving shimmers—we had to focus as much on taking these in, when and where we could, as on navigating the dying stream.

At the Labyrinth, shimmers still appeared in large quantities, but there were breaches along the streamlet edges that hadn't been there before. Softbody invaders were everywhere, with hardly a warrior or a softbody soldier to battle against them. At one point, we experienced violent motions. Then we were out of the Labyrinth, through the second turbulence, and beyond it.

The mightiest stream of all—it was choked with dead and rotting softbody things, including Invaders, dead from the blight. Shimmers were abundant for a time, and desperate warriors, scouts, and thids ravenously ingested them. Other shimmers were taken up by the rotting softbody things in the stream. There seemed no end to it, the whole world that we had known was near to death.

What to do? I contemplated our world as it had once been, forever now encoded in my spatial neurals; and I was suddenly, acutely aware of a tantalizing, strange fact. Our world extended so far, and no farther. It had . . . boundaries. *What lay beyond? Could the three of us—Scoutkn, Thidkog and I—traverse the outer softgrowth to reach these boundaries? Once there, could we find the means to save ourselves from the death and rot within? I did not know. But with our world near to death, what else could we do but try?*

I conjoined with Scoutkn and loyal Thidkog. Scoutkn was hesitant, but I finally convinced my gentle comrade that we had to try. Thidkog had total faith that my plan would work, had total faith in me. As always.

We went to the edge of our world, filled our stomachs with shimmers and food things, then started to lascut outward. We tunneled single file, making the smallest opening that we could fit easily through. Thidkog and I alternated taking the lead, and Scoutkn—with no lascutting capability—stayed between us.

The cutting through was long and arduous, and toward the end I became alarmed: my shimmer stomach was almost a third empty, my other stomach almost as far drawn down; and we would need reserves for whatever lay ahead in the outworld. Scoutkn shared shimmers and food things with Thidkog and me, to even up the stores, and then suddenly we broke through.

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We looked outward into an endless void, illuminated by distant, diffused lights, arranged in a line. The lights seemed to be moving, though just perceptibly. We turned off our eyes, yet from the distant illumination, we could still see. Passively, now, without lasing we looked about, hoping to behold worlds like our own, but saw only vague, distant shapes. Which like the lights, seemed to be moving. We waited. Hoped for deliverance, not knowing what form it might take. Our prospects here in this outworld seemed hopeless, yet there was only death and rot the way we had come.

We communed, the three of us, and formulated a plan. We would lie dormant to conserve shimmers and food things. Total dormancy for Scoutkn and Thidkog. Semi-dormancy for me—I would keep one eye and a few neurals active. Periodically, we would trade roles. When our stores of shimmers or food things were two-thirds depleted, we would backtrack along the still open lascut in the hope of gathering more.

We moved very close together and awaited our common fate.

In a state of dim awareness, an eternity passed . . . vague shapes and distant lights moving slowly in a line. I awakened Scoutkn from total dormancy, put myself into it. Time vanished, and an instant later it was my watch again. Distant lights and shapes in the void, moving in a line, as before. An enormous, indefinite shape very slowly drew close, started to block one of the lights. A second eternity, and the shape occluded additional lights, blocked all else from view, and started coming into focus. Closer. It was the same light color as the softgrowth upon which we waited. Closer yet. I saw a mesh of lines and rises and depressions. It grew dark, and I turned my eyes on. Presently, massive softgrowth—not of our world—pressed down upon us.

I turned on my dormant neurals, then the rest of me, and awakened Scoutkn and Thidkog from dormancy. Follow me, *I sent, conjoining with Scoutkn, then Thidkog. I attached to softgrowth above us and started to lascut through, Scoutkn and Thidkog following close. We tunneled for a long time, then Thidkog took the lead, and my loyal companion was still in the lead when we broke through onto a tiny streamlet. What a glorious little flowage it was—ubiquitous shimmers, not a dead soft-body thing in sight. We feasted in celebration.*

We had entered a new world, it appeared. I was eager to resume living the good life with gentle Scoutkn and loyal Thidkog. And perhaps a few warrior compeers, in a time to come. After looking about, we decided that the region we had chanced upon was well suited to us; so we burrowed into the softgrowth, and for a long time reflected on what had happened.

Questions arose. If indeed, we now resided in a world something like the world we had left behind—before the dying had started; then what of the sapient Presence? Did a separate Presence reside in each separate

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world? The prospect was disquieting.

The Presence cannot die, *Scoutkn asserted to me during an insightful commune.* Therefore—although the Presence resides in each world, it is everywhere, as well. *I reflected on Scoutkn's assertion, and ultimately came to accept it.*

We contemplated the Master. The tyrant's demise in the dying world we had left, it seemed, would be of no great loss in the grand scheme of the sapient Presence. But then we wondered—Did a second Master reside in this new world? We had to be on guard.

I imparted to Thidkog the musings that Scoutkn and I had shared. Slow thinking Thidkog did not grasp it all, but was grateful to me for having been included.

Scoutkn and I communed further, but presently it became clear that we needed new facts, other perspectives, fresh insights. The time had come to explore our new world; and following that, a few liberations would be in order. We realized the danger such liberations could pose. Overpopulate this new world with active, shimmer-devouring warriors, scouts and thids, and perhaps this world would die, as had the first. Much as our compeers deserved to live in liberty, as did we, limits would have to be set.

Starting out on our journey of discovery, we passed the narrows and entered progressively larger channels, and presently saw unliberated warriors. An inquisitor approached Scoutkn and me, but moved on, satisfied, after seeing a thid in our company.

Still early in our exploration, we were attached to the softgrowth, communing, when a group of several hundred emancipated *compeers came pushing spiritedly down the stream. A warrior moved toward us. I responded with deviant type body language, then made the half-rotation which signaled Warrior that I wanted to conjoin. Which we did. Five of their group, I learned, had crossed from the same dead world as Scoutkn, Thidkog and I. The others, all freshly emancipated, were indigenous to this new world. The incipient crusade was now adding liberated compeers at almost a geometric rate. We were urged to join in.*

I cautioned Warrior against overpopulating our new world with emancipated compeers, but was confidently assured: There are other worlds than this one. The Presence will provide. *It was futile to argue, and so reluctantly, we joined the group. Later, perhaps, our arguments would hold weight.*

Having received directions from the security guard, Frank Gonzales, thick-chested, with dark eyes, started down the hall. Sent by the surgeon general himself, he was resolved to get to the bottom of this appalling, volatile situation.

It had been intended that all meeting participants be outfitted with biohazard suits and breathing tanks, but the governor had phoned Frank to say she'd changed her mind. The nanomedic scientist who would attend, it turned out, hadn't actually been in close proximity to the primary sub-

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ject, Lorna Jacob. She had met with Doctor Zugart shortly after Lorna had died, but that was well before Zugart showed symptoms of the plague. Also, the meeting complex was a good five miles from the hospital and the air was calm, so there was little immediate danger from wind-borne contamination.

When Frank Gonzales stepped inside, there were five others in the room: the governor and her assistant, the hospital chief of staff, the Nanomedic scientist, and the CEO of the company. Following the introductions (they agreed not to shake hands or make other physical contact—just in case), they took seats at the large, oval oak table. A young woman appeared with coffee and a stack of Styrofoam cups. As she poured, Frank studied the two from Nanomedic. The media would grind up his boss, for sure. And himself. Maybe even the president—and it was an election year. He started to get angry. Nanomedic had plenty to answer for.

"Let's get on with it," Governor Rita Moraski said, sipping coffee. "Tim Riley, whom you just met, will let us know where things now stand." Moraski, at age seventy, was the youngest governor in the state's recent history. But right now, implant system or not, she looked rather worn.

Riley slid a viewgraph on the projector and a map of the city appeared on the wall. Six areas were outlined in red. "Area one includes the hospital," he began. "Staff and patients inside when Doctor Zugart and Nurse Jepson came down with plague, were quarantined there; and the complex was surrounded by militia in biohazard suits. That might have contained the plague, had the orders been given in time. Unfortunately, Governor Moraski wasn't told the desperate nature of the situation—"

Frank pointed suddenly at Jim Owada, the hospital chief of staff. "In view of the quarantine, may I ask what you are doing here?"

"Doctor Owada was out of town and couldn't have been exposed," the governor interposed. "Now he's our phone contact with the hospital. . . ." Her eyes shifted to Owada. "Doctor, what is the situation there?"

Jim Owada, a short man of Japanese ancestry, shook his head sadly. "The hospital population has been largely lost to plague. There are pockets of survivors in sealed-off rooms, mostly staff; but it's probably only a matter of time."

"Yes . . . well, bad as things are inside the hospital, that isn't our main problem," the governor said. "Please continue, Tim."

Tim Riley pointed at a second red-marked area. "Sam Jacob's house, plus four city blocks around it. We started out with a few houses encircling Jacob's; but then people started dropping like flies in a half-block region, so we drew the red boundary you're looking at, and sent militia in to surround the area. The militia designated the boundary streets a biohazard break, and barricaded them. Anyone attempting to move along or across those streets is hit with heavy firepower."

He tapped the other red-marked

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areas with his finger. "Spreading either from the hospital or from Jacob's neighborhood, plague showed up in four other parts of the city, and militia were sent to these areas, also. About then, everyone else in town who could, got into cars and headed outbound. Except for the red areas, the city's pretty well deserted now."

"Thank you, Tim," Governor Moraski said. Her attention returned to the group. "I've talked to the president; he's in the process of sending in regular army. You were sent—" she nodded at Frank "—before we knew how bad the situation really was. I'm expecting some real heavyweights to start showing up. In the meantime, let's work up some ideas on stopping this thing."

Frank glared at Jane Hammer and Thorton James. "I, for one, would like to know just what in the hell *you* people have in mind to do. I understand it's your company's damnable system that's screwing up."

Thorton James smiled nervously. "We're not willing to say, officially, that the Nanomedic system is at fault. We'd have to run a variety of tests first, and then—"

"Damn it! Spare me the weaseling." Frank's eyes fixed on Jane Hammer. "What about it? Are you going to weasel, too?"

Jane's face reddened. "I don't have to take your cra—!" She bit her lip, took a deep breath. "I've been on the phone the last two hours with research. We're working up ideas, but it will take time—"

"Which we don't have—"

"Please, this is going nowhere," Moraski broke in. "Jane, give us your best thinking on what's going on."

"OK, Governor Moraski. Let's review what happened: Doctor Zugart, in trying to save the life of his patient, Lorna Jacob, switched out her implant. When that didn't work, he ultimately gave her a second charge of nanomeds. The fundamental problem was—there was no way to withdraw the nanos she already carried. Which had mutated—"

"What the hell does that mean?" asked Frank.

"You'll need background facts on the nanomeds to understand any of it," Jane said curtly.

"Go ahead," he shot back.

"OK. There are three types of nanomeds in a charge. Two, the workers and monitors, directly perform H-M, health maintenance, and are self-reticulating—"

"What—?"

"The term has to do with the interconnecting of neurals. What I'm getting at is this: We think that a nano reticulated in a way that gave it cognition beyond its health-maintenance function, became what we term a mutant. A charge includes control nanos that deal with that, by breaking the mutant's neural connections. Yet somehow that didn't occur, and the mutant infected other nanos in a sort of chain reaction. In Max Stonewall's words, a 'runaway mutation event' occurred. During the approval hearings on the system, years ago, the company said it couldn't happen, but—"

"There's no need to get into *that* aspect, Jane," Thorton James

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squirmed.

"Yes . . . well, as to Lorna's deterioration, keep in mind that metabolism-wise, a nanomed mimics the human cell. That is, it takes in bloodstream oxygen, nutrients, and enzymes to generate energy, and discharges carbon dioxide. As relates to our problem, oxygen consumption is the key—carbon dioxide elimination being merely the flip side of the same coin."

She walked to the viewgraph machine, slipped a diagram onto it that showed a cutaway of a human heart, plus surrounding regions. Two green rings were highlighted, one inside each *vena cava*. "The implant rings, you may be aware, are commlinked through the right atrium. Monitor nanos circulate the body and report infections, cancers or whatever to the implant, then locate and activate workers as the implant dictates. The implant sends the workers where needed.

"Call it design overkill—a charge contains twice the number of nanos needed for a worst-case scenario. In fact, the nanos in a single charge—99 percent of them workers—weigh-in at almost a pound. They consume oxygen, and do so rather inefficiently. But with the vast majority of them normally kept dormant, semi-dormant if they're workers circulating to disease sites, the added oxygen consumption isn't a great burden to a person.

"With the runaway mutation, all of that changed. The outcome quickly became even worse than Stonewall had feared, because the nanos—for reasons unknown—went hyperactive, and oxygen consumption shot sky-high. And from the scans of Lorna Jacob that Doctor Zugart showed me, the mutated nanos clumped together in certain areas—again, for reasons unknown. The tissue in these areas died from oxygen deprivation, and the process just kept progressing.

"What really confounds us, even given all of that, is how this runaway mutation is jumping from one person to the next. Remember, the mutant nano is hyperactive. Once out of a person's bloodstream, it would burn its internal stores of oxygen and glycogen, etcetera, in a few seconds. And after that occurred, the nano would shut down permanently. So given that, what's the chance of it being able to infect the nanos in a second person? Maybe if you had direct mixing of blood—but otherwise? It doesn't make sense. . . ."

"OK, much is happening that we don't understand," Governor Moraski summarized. "What I want to know is—how can we stop this thing?"

"Please realize, Governor Moraski," Jane said, "that the inventors of the Nanomedic system have mostly moved on to other things—"

"Let's not waste everyone's time with internal company matters, Jane," Thorton James said testily.

"Very well. To address the question, then, we do have some ideas. For one, there's a possibility of developing filters to remove the mutant nanos. And ultimately, we may be able to invent special nanos that destroy the mutant ones. Then we follow up with charges of *safe* nanos."

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"How long will all of that take?" the governor wanted to know.

"We're predicting six months —considering the urgency."

"Six months?" Frank scoffed. "What is a person's life expectancy with the plague?"

"A few hours," Jim Owada responded. "Once the symptoms show up."

Frank shook his head, incredulous. "Maybe we'd best look for interim solutions."

"Such as?" Jane Hammer said coldly.

"I don't know—but I do know we haven't got six months."

For a time everyone sat thinking. That was before the president walked in.

We are exploring our fourth world now—Scoutkn, Thidkog and I. The worlds of the sapient Presence are each the same, but different, too. The second world was similar to the first, yet lacked certain regions of the first. and had regions the first lacked. The third world was similar to the second, yet was less than half the second world in size. And our newest world is very similar to the first. The Presence gives us stimulating variety, yet comforting sameness, both at the same time.

Our compeers of this newest world can be grouped in four ways. The vast majority are warriors, scouts and thids, indigenous to this world, whom we liberated in the name of the Presence. For a very few —Scoutkn, Thidkog and me included —this is our fourth world. A larger number started out from our second world, and a still larger number were native to our third.

Crossings, one world to the next, have been made in numerous ways, and from our individual experiences and communing with our compeers, we are developing certain strategies. Henceforth, we shall cross in great numbers. Once outworld, watchers will revive the dormant masses when the time is right, and the watching task will be rotated. The strategy will stretch, by many orders of magnitude, the time we can wait for a Crossing opportunity.

Regarding past Crossings, we speculate endlessly as to the fate of the compeers left behind. Did they slip into the life-death when their stomachs ran empty? Or did they cross to a myriad other worlds of the sapient Presence, to live in enlightenment, as do we?

The tenth world, now, for Scoutkn and myself. Loyal Thidkog . . . lost during the Crossing from world nine. We are very sad, and can only hope that somewhere, Thidkog still lives.

The communing process continues. As we accumulate knowledge and our neurals become endlessly more reticulated, a few of us also gain humility. For a time, in our euphoria from making Crossing after Crossing, we came to regard our future as ordained, inviolate. If we caused a world to die—no matter: there would be a next world, and a next. The Presence would provide. I am encouraged that this early zeal and arrogance shows signs of fading, and that

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a new thinking has emerged.

Jane Hammer gave Frank Gonzales the VIP tour of the lab, introduced him to her new people, then they chatted in her office.

"I hope you don't mind that I dropped in unannounced," he said.

"No, not really," she lied. He had totally disrupted her afternoon schedule, but with Frank Gonzales, you wouldn't expect common courtesy.

"I need to get a quick run through on where you're at," Frank said, reading her mood. "We're under pressure from the White House. Any success so far?"

"I wouldn't use the word 'success.' However, we do have some interesting test results. By the way, we're thinking the Utah incident was a dead-ended plague situation. Two deaths—"

"Yes, I had heard talk."

"Back to the tests, then. We've experimented with filters. Also the corrective nanos we talked about a few weeks back—"

"The nanos are functional already?"

"Functional, and have been tried out on eight different volunteers. No luck so far."

"That's too bad," Frank empathized.

"It's discouraging," she said. "When we IV in a corrective charge, the nanos stir up the mutant ones the subject carries—"

"Stir them up?"

She reflected a moment. "Standing outside our sliding-glass door, when I was fifteen, I backed my head into a huge yellow jacket nest that I didn't know was there. A hundred of the bastards nailed me as I ran off screaming. That's the sort of stirring-up I'm referring to."

"I read you," he smiled.

"If we fit the corrective nanos with the standard hermaphroditic couplings, then in the end, the mutants infect the nanos we inject, rather than the other way around. If the subject survives sudden oxygen deprivation from the stirring-up, he ends up with twice as many mutants. If we fit the corrective nanos with noncompatible couplings and rely on laser means to eradicate the mutants, there's a real donnybrook and the subject dies quickly and painfully. We lost the first two persons who volunteered, both of them lifers from the penal system. . . ."

"What happens if you reduce the dose?"

"We tried that. At an extremely low dosage, oxygen deprivation is tolerable, but the corrective nanos are destroyed. The subject reverts to having the same plague manifestations as before the infusion. We're still playing with it."

"What about the filters you mentioned?"

"No luck at all with that approach," she said. "The mutants head back up the artery or vein the way they came. It's a total energy blow-off—you wouldn't believe the oxygen they consume."

"It's a bizarre situation," Frank said. "You don't suppose that the plague will go away on its own?"

"You mean after we're all dead?"

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Frank winced.

"Sorry . . . Actually, you have a point. Since the outbreak of plague the mutant nanos have kept right on mutating, and now, not every person infected is dying right away—"

"Any way to accelerate that trend?"

"How?"

"I don't know. I was just thinking, though—you've tried exterminating the critters, and that hasn't worked. Maybe more subtle approaches would work."

Jane Hammer smiled to herself. The man was a fine one to be talking about subtleties. But she reflected further on what he had said, and an idea started to take shape.

It was well past midnight and the phone kept ringing. Finally she heard a sleepy "Hello" at the other end.

"Frank, it's Jane Hammer," she said, her voice cold as death.

"Huh? What . . . ?"

"Frank, I've come down with plague."

"My God!"

"I've been working up a treatment idea. If I can hold on a while, I'll try it out on myself."

"What—?"

"It'll all be documented for posterity in my lab notebook. I just wanted to let you know my status. And that we've put the lab under quarantine—I'm not the only one here with plague. . . ."

Another Crossing, and another. The new thinking gathers momentum, though in truth—most compeers still scoff at it, convinced that the Presence will eternally provide, come what may.

The new thinking explains: We are not so important and grand in the scheme of things that the Presence will give us worlds without end to despoil and kill. Instead, we must protect and make right that world we presently live in.

Perhaps the loss of loyal Thidkog has chastened me, but I am coming to believe—as is gentle Scoutkn —that the old ways were not entirely bad. We lived in slavery; and yet—we conserved the precious shimmers, kept our world alive and robust. Kept ourselves alive, in return. We would never consent to live as slaves again. But we wonder —could we not protect and make right our world, and still live in freedom? We search for an answer.

As we travel our world, some of us now use the currents more wisely than before. We no longer push hard upstream—as oftentimes we did, for the sheer joy of it, in a time past. And if one warrior or scout has traveled and registered a stream, a second warrior or scout need not do the same. Not when the knowledge gained can be shared through communing.

Our individual cognition lobes keep developing, and now we think with less difficulty than before, with less consumption of the precious shimmers; and we have learned how to keep dormant those regions of our neural lobes not actively used. We turn our eyes off, oftentimes, while we commune.

Some of us now work willingly to

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keep our world robust and in good repair. We fight the softbody Invader and the Hungry—as in the time of old, when the Master's inquisitors were about. Perhaps we will yet learn to live in harmony with this world of ours. Or the next world, or the next one after that. I am hopeful.

"Have a seat," said Jane Hammer to Frank Gonzales. A meeting on the plague was scheduled for 10 A.M., and Jane, in the hotel restaurant, had just finished her oatmeal, toast, and juice, and was ready for a second cup of coffee.

"Thanks," Frank said, smiling. He sat down opposite her, caught a waitress's eye and turned up a cup. "The new CEO make it in?"

"Oh, sure. He usually skips breakfast, though."

Frank Gonzales had come across to her as an arrogant smart ass, that first panicky meeting, three months earlier. But from all those nice phone calls after she was smitten with plague—she'd changed her mind. She was glad to see him again.

The waitress arrived with a steaming pot. "You all set for this morning?" Frank asked Jane.

"I guess so," she said, sipping coffee. "And by the way, Max Stonewall is flying in for the meeting. He's back with Nanomedic, I'm happy to say."

"Excellent."

"You've taken your shot?" she asked.

"You bet. The moment I showed plague. By the way, you're looking good."

"Thank you. I gave myself the first shot, so I had a head start on the process."

"In the media, they're calling what you came up with a miracle cure."

Jane frowned. "They've got it wrong, as usual. The vaccine is no cure. It doesn't affect the mutation process, per se, either, it simply mitigates plague damage."

"Some mitigation, I must say. Do you intend revealing the deep, dark secret of the vaccine today?"

Hammer nodded. "I wanted to be certain of how well it was working, first."

"Well, now that you know, please let me in on the secret."

"With great pleasure. Frank . . . *you* gave me the idea for the vaccine with your talk about using subtler approaches."

"I did—?" He looked puzzled.

"So given the mutants' convincing responses to nanos that tried to disconnect their neurals or laser them, I thought to inject something nonthreatening. Something actually beneficial to the mutants."

"Such as?"

"The vaccine, Frank—it's pure data."

He looked more bewildered than ever.

"Let me explain. . . ."

"Please."

"Remember that day at the lab? I mentioned that, with the mutation process continuing, not every person infected with plague was dying right away. And you wondered about accelerating that trend."

Frank nodded.

"Thinking on it, it seemed just pos-

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sible that the trend reflected a growing awareness by mutant nanos that host-death outcomes ran contrary to their interest. They did, of course, since relatively few mutant nanos escaped to infect additional persons. But to what degree were the mutants cognizant of this? Could they somehow be made more cognizant? Could data on the mass extinctions of nanos within plague victims be imparted to mutant nanos infecting living persons, to provide grist for their thinking?

"To impart data, one must use nanos fitted with the standard hermaphroditic couplings. It was vital that the data be believed, and it seemed me that a mutant nano would find a second mutant far more credible than any nano I might program up. So we brought in plague cadavers and extracted the extinguished mutants—these mutants having experienced their own 'deaths,' and the deaths of countless other mutant nanos. I won't go into the grisly details. We revived these nanos using nanos created for that purpose, and put them in cultures, in large numbers—"

"Why do that?"

"To disseminate the data. I wanted each of the revived mutants to be aware of the repeated extinctions resulting from their excesses. Using them as a vaccine, the mutants in an infected person would then absorb what they had experienced, and use this information to their benefit. And, of course, the benefit of the person vaccinated. Or so I hoped. I didn't know that it would actually work in practice, until I tried it on myself.

She sipped more coffee. "Have you seen this morning's stat sheets on the plague?"

"Not yet."

"Things are looking better all the time. A good portion of the implant-carrying population has been infected by now. But no one is dying. And for those who have been vaccinated—the documentation's getting quite solid on this—the mutants are causing a low-grade oxygen deprivation and what goes with it, but not much else."

"That sounds about right," Frank said, a finger on his wrist, getting a pulse count.

"As the nanos keep on mutating, even those effects are decreasing. Take me—my pulse rate has dropped three counts from a week ago, and my temperature's down nearly to a hundred. If you project what's been happening—a month or two from now, the mutants will likely cause us few problems at all. As long as—"

"Yes, we wouldn't want to stir them up.

Jane grinned. "As best we can judge, the mutants are starting to give us the same protection as before this business started." She drained the last coffee from her cup, reflected on all that had happened. "You know, Frank, before this mutation thing came about, our relationship with the nanos was all one way—them working for us. But now, it seems, we're settling into a kind of symbiosis."

"A symbiosis, huh? That's an interesting way to put it."

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"It's accurate, Frank. They keep us disease-free and young, and we furnish them with energy and a splendid place to live and grow ever more aware, or cognitive, or intelligent, or whatever. The damn things won't wear out for hundreds of years, so maybe we're just stuck with each other."

"Is that what you're going to tell the president?"

"Sure, why not?"

"Well, Jane, you might want to pass on the symbiosis thing. We don't know what you or someone else might come up with down the road, do we?"

"Or what the mutant nanos might come up with," she said.

"Point well taken. Still, maybe it's premature to be overly pessimistic. Besides," he winked, "it might be unwise to get the president all worked up. *His* temperature's still running 102, and he's slipped in the polls again. He's short-tempered as hell from all of it."

"You also have a point," she laughed. ■

The facts will eventually test all our theories, and they form, after all, the only impartial jury to which we can appeal.

Louis Agassiz

Everything that is alive forms an atmosphere around itself.

Johann Wolfgang von Goethe

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Labyrinth of Night, Allen Steele, Ace, $4.99, 340 pp. (ISBN:0-441-46741-5).
Kalifornia, Marc Laidlaw, St. Martin's, $18.95, 245 pp. (ISBN: 0-312-08830-2).
Triumph, Ben Bova, TOR, $18.95, 253 pp. (ISBN:0-312-85359-9).
Lady Slings the Booze, Spider Robinson, Ace, $18.95, 257 pp. (ISBN:0-441-46928-0).
Agyar, Steven Brust, TOR, $18.95, 254 pp. (ISBN:0-312-85178-2).
Omni: Best Science Fiction One, Ellen Datlow, ed., Omni Books (324 West Wendover Avenue, Suite 200, Greensboro, NC 27408), $8.95, 267 pp. (ISBN:0-87455-277-X).
Ark of Ice: Canadian Futurefiction, Lesley Choyce, ed., Pottersfield Press (RR 2, Porter Lake, Nova Scotia B0J 2S0 CANADA), $14.95, 287 pp. (ISBN:0-919001-73-4).
A Wealth of Fable, Harry Warner, Jr., SCIFI Press (Southern California Institute for Fan Interests, P. O. Box 8442, Van Nuys, CA 91409), $?, 456 + xiv pp. (ISBN:0-9633099-0-0).
Zombies of the Gene Pool, Sharyn McCrumb, Simon and Schuster, $18, 208 pp. (ISBN:0-671-70526-1).
Chronicles of the Mutant Rain Forest, Robert Frazier and Bruce Boston, Horror's Head Press (George Hatch, 140 Dickie Avenue, Staten Island, NY 10314), $8.95, 80 pp. (no ISBN).
Books on Disk

In 1976, the Viking orbiter photographed the surface of Mars. Its pictures of the Cydonia region showed several strange objects, one of which looked remarkably like a human face. Others resembled Egyptian pyramids.

The first reaction was to dismiss these strange things as tricks of light and shadow. If the objects were real, their artifactual appearance was sheer coincidence. They *had* to be natural phenomena, for there was no life on Mars and visiting ETs seemed a mite farfetched.

However, a few people were not satisfied by those arguments. They insisted that ancient Martian natives or

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visiting ETs were real possibilities and that the face and pyramids deserved at least a closer look.

Since manned expeditions to Mars aren't in the cards for a long time yet, the questions have remained unanswered. That is, they have left plenty of room for the play of imagination and the writing of science fiction stories. And that is just what Allen Steele has done in **Labyrinth of Night.**

His premise is that manned expeditions did indeed go to Mars early in the twenty-first century. When they reached Cydonia, they found that the face and pyramids were indeed made things. What's more, one of the pyramids contained the scattered remnants of the alien builders, the insectile Cooties. Another contained a maze of chambers that can be entered only after solving puzzles apparently designed to test intruders for intelligence. The final chamber's test was something else, however; it was solved only when the humans imported a musician from Earth. And then the Cooties, or their robotic avatars, woke up.

The human investigators of the mystery are an international group of scientists with a few military types thrown in to satisfy the demands of politics. Not surprisingly, each government involved would dearly love to gain the Cooties's secrets for its own. Efforts to establish and defeat military dominance thus provide a level of tension and action beyond that of Steele's central mystery. So does official military paranoia.

What are the Cooties's robots building deep below the pyramids? They're building *something*, for the commotion registers on seismographs. But they destroy any human agent—live or not—that attempts to spy. And then the news from Cydonia dries up, not long after the arrival of a notoriously ruthless U.S. officer, Terry L'Enfant (might Steele be hinting that Terrans are childish?).

The corporations whose money is funding much of the effort on Mars engage private security agent August Nash to find out what is going on and, if necessary, to terminate L'Enfant with extreme prejudice. Unfortunately, L'Enfant recognizes and disarms Nash on arrival. Nothing remains to stop him in his paranoid scheme to destroy the Cooties and all their promise.

Of course, Steele sees to it that L'Enfant does not succeed. The Cooties have their own tricks up their sleeves, including a way to recycle the plutonium in a nuclear bomb. No one is about to upset the agenda they set millennia past.

Unanswered questions, high-tech, hard-science SF, adventure, and action—how can you fail to enjoy this one?

Marc Laidlaw's first novel, *Dad's Nuke*, was cock-eyed, manic, bizarre, satirical, and generally worthy of praise. His second, *Neon Lotus*, was just as off the wall, and its extrapolations could short your pacemakers.

His third novel is now here, and **Kalifornia** is pretty strange too. Once more, Laidlaw's target is modern America, especially as seen in California, with emphasis more on show-

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biz and media manipulations than on suburbia. Does he hit the target? Well, it's not really a very difficult one to hit. It's also fairly popular. Does he bring anything new to the firing range? Not as much as he has done before—in fact, he even uses a superbaby as he did in *Nuke* and a bit of boodoovoodoo as he did in *Lotus*. So his novel is not quite novel enough to satisfy expectations raised by past performance. Nor is it as "wildly funny" as the jacket copy claims; I didn't laugh once. Nor is it as SFnally strong as I think it should have been; Laidlaw's gizmo gimmick has a nasty way of acquiring new capabilities just as the plot requires them rather than as an inherent function of the posited technology, and any resemblance to plausibility is purely coincidental.

On the other hand, if you missed the earlier novels, you're likely to enjoy it. As satire, the book works pretty well even though it often seems quite heavy-handed.

Laidlaw's basic premise is that technology will make it possible to grow synthetic nerves (polynerves) within our bodies. Their chief use will be to transmit the experiences and points of view of actors (wired to send and receive) to the public (wired to receive only). Showbiz has therefore filled the airwaves with programming of all sorts, including family sitcoms such as the one that tracked the Figueroa family until mother Margery died in an accident on the Moon. Now daughter Poppy has her own spin-off, "Poppy on the Run," in which the minions of archfiend President McBeth pursue her endlessly. The latest gimmick for this series is Poppy's daughter Calafia, wired to perform while still in the womb. Unfortunately, immediately after birth she is kidnapped by minions of the man-hating Daughters of Kali, who see her as their destructive goddess incarnate.

Poppy's family rallies round. Omens hint that Poppy's wirist (cameraman/producer/director equivalent) was suborned long ago. Brother Sandy, assisted by Cornelius, a sealman who cannot swim, finds clues that the baby disappeared in the Holy City, that portion of the vast Frangeles hyperopolis that has surrendered to ruins, crazies, and fanatics of all kinds. He permits himself to be drafted by a sect of Celestial Mechanics who love all things mechanical and are building a four-armed robot body that can be operated by a small, wired human being.

Laidlaw reveals early on that the send/read distinction in polynerve functions is hardly absolute. Audiences can provide feedback to performers or politicians at the *latter's* whim. Polynerves thus offer an avenue of control. He also raises the issue of living vicariously through celebrities, that is, of one life serving for all. And that's all I'll hint about the end of his story.

Ben Bova's **Triumph** is one of the best bits of alternate-history fiction I've seen in a while. He has chosen to rewrite the spring of 1945—just before the fall of Berlin—as if Roosevelt lived and Stalin died. He had a good deal of fun doing it, and the re-

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sult is rather more gripping a page-turner than anything else he has ever done. In saying that, I do not to mean to knock his previous works, but to praise this superlative political thriller.

Is it SF? Churchill sets up the assassination of Stalin by concealing a wafer of plutonium in a war trophy. The man who eventually puts the wafer where its toxic emanations can do their work is the father of Yuri Gagarin, and we do get to meet that future cosmonaut and witness his enthusiasm for Konstantin Ivanovich Tsiolkovsky, rocketry pioneer. So there are SF connections. But no, it isn't really SF.

Does it really matter?

About a year ago, I reviewed Spider Robinson's short novel, *Kill the Editor*, saying things like "rife with puns both verbal and visual . . . fond homage to the hard-boiled detective story and to John D. Macdonald's classic *The Girl, the Gold Watch, and Everything*, . . . a breezy bit of fluff with a very entertaining raunch level."

The same things are still true though the story grew a bit on its way to becoming **Lady Slings the Booze**. The narrator is still "Joe" Quigley, a private eye with the unique ability to see what makes sense, and as soon as he has solved Lady Sally's mystery, he must save the world by realizing terrorist peaceniks have salted the world's water mains with nuclear bombs. If you recall that though Joe sees the big picture better than anyone else, he always fails to spot some essential detail, you can glimpse the trouble he is about to get into. Fortunately, that trouble is now outside the brothel.

Spider's breezy style doesn't work very well when he hands his characters the death of loved ones, but overall it works quite well enough. You will therefore be happy to notice, at the end of this book, a strong hint that there will be more Quigley adventures.

Steven Brust's **Agyar** is a strange and satisfying treatment of the vampire.

Not that Brust ever tells you flat out that he's talking about vampires or lingers over the luxurious sensations of filling one's gut with another's lifeblood. He begins with Jack Agyar, a strange fellow who has found a typewriter in the attic of the unoccupied—except for a gentlemanly ghost named Jim—house he has chosen for his lair and begun to record the current events of his life. He shows us immediately that Jack has a way about him, for he can persuade a young woman to abandon her beau and go with him without apparent effort. He is a seducer, a manipulator who leaves his women gasping in his wake. There seems nothing supernatural about him at all, even though he is such a polite fellow that he always waits for the woman to invite him in.

Jack's first victim is Jill Quarrier. Then he meets her housemate, Susan Pfahl, and he falls in love. In due time, Brust has him tell us of Laura Kellem, the woman who summoned him to this chilly Ohio university town in order to be her sacrifice to the forces

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of law and order. She has, it seems, been careless. And he has no choice: He *must* obey her every whim.

It doesn't really take very long for the reader to catch on. Jack is a vampire. So is Laura. In fact, she is the very vampire who made Jack what he now is, and that relationship is indeed one of power. Whether he loves her or hates her, he must obey, even if it means his "life." The only avenue of escape is if she voluntarily frees him of all obligation to her.

Or is it? Jill must obey him, and it becomes obvious that their relationship distresses her. Then, one day, he becomes aware that she is doing something that shakes the link between them. Rushing to her, he finds her performing a magic rite intended to free her, and it seems quite likely to succeed. After he stops her, he learns who told her what to do: an ancient Gypsy woman.

There are more deaths in the city. The cops stake out Jack's haunted home. Jack's bond to Susan ripens and strengthens. He visits the Gypsy himself. He confronts Laura, faces the need to choose between Jill and Susan, and then . . .

Beware the frabjous cover blurb. This book's hints at ancient, malicious, deliberate evil. Yet for all Jack Agyar's sinister ways, he is a very sympathetic character. The conditions of his life are different from ours, yet he is not that different a person and he is more capable of self-sacrifice than many.

Omni: Best Science Fiction One, edited by Ellen Datlow, is an interesting combination of old and new. Four of its ten stories first appeared in *Omni* magazine. They are "Diner" (1987), in which Neal Barrett, Jr., tells of an America ruined by a biowar blight and now under the helpful thumb of the Chinese; Jack Dann's "Tattoos" (1986), where memories of the Holocaust can be a two-edged sword, or scalpel; Tom Maddox's "Snake Eyes" (1986), which tells us something of how even an artificial intelligence must crave an animal nature; and Suzy McKee Charnas's "Listening to Brahms" (1986), in which she suggests that when the pain gets too great to bear, the best we can do is lay back and turn on the stereo.

The new stories begin with Elizabeth A. Lynn's "California Dreaming," about the feelings that will prevail when private automobiles are eventually banned. Richard Kadrey's "Horse Latitudes" posits a compensatory explosion of the rain forest into North America, particularly California, and says that the music of the land has necessarily changed and must be sought. Bruce McAllister's "Sister Moon" would have us believe that the monks of the Order of Saint Francis of Assisi will become assassins in defense of the environment —albeit an exceedingly unrealistic, sanitized environment; the nature of his assassin's opponent hints that McAllister thinks that religion has its most debilitating effects on the male mind. Robert Silverberg's "The Perfect Host" concerns an invasion of microscopic, beneficial aliens. Paul Park's "The Lost Sepulcher of Huascar Capac" blurs the boundaries of reality

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for an obsessive memorizer. J. R. Dunn's "The Heart's Own Country" deals in a fairly ordinary way with the aftermath of a total ban on biotechnology (thanks to a plague).

These stories are all well done, excellent examples of their kind. But only two—"Tattoos" and "Sister Moon"—struck me positively enough that I could recall them two days after finishing the book.

Lesley Choyce is a one-time New Jersey-ite who teaches part-time at Dalhousie University, writes (20 books in print), surfs year-round in the North Atlantic (that's what his bio says!), and runs Canada's Pottersfield Press. In that last capacity, he has just released **Ark of Ice: Canadian Futurefiction**, an anthology of SF by Canadians who write in English. The list of contributors includes Choyce himself, native Canadians such as Robert J. Sawyer and Phyllis Gotlieb, Canadians living in the States such as Garfield Reeves-Stevens, statesiders living in Canada such as Spider Robinson, and a transplant or two from England such as Andrew Weiner.

I find it curious that the editor feels it necessary to put such place-of-origin information in the book's "About the Contributors" blurbs, but I have to admit Choyce's choice does reflect one distinctive feature of the way Canada looks at the USA. There is a powerful defensiveness, as if Canadian writers expect to be regarded as inferior to USA writers. Or . . . well, consider—most of the names I mentioned above are quite familiar, aren't they? You see them in magazines and books published in New York. They're *American* writers, by which most people mean *US* writers. "And dammit," say the Canadians. "We're *Canadian* writers. And don't you forget it." It's a question of identity, even for the transplants. Something like a SF writer roaring at being lumped in with the fantasy or horror writers.

You won't be disappointed with the book. The standard of quality here leaves nothing to New York's advantage. The differences lie in sense of place; an air of defensiveness visible in the book's part titles (Macroethics, The art of escape, Eco/logical, and Political alienation) and nowhere stronger than in Timothy Findley's "What Mrs. Felton Knew," in which a bossy urban culture exterminates its rural roots; and focus on Canadian concerns; never in sheer excellence. None of the twenty-two stories, most of them original here, left me cold, though of course I liked some better than others.

All in all, an excellent buy.

Harry Warner, Jr., active SF fan since 1936, recorded the fandom of the 1940s in *All Our Yesterdays* (Advent, 1969). In the mid-1970s, he covered the 1950s in a three-volume fanzine. Now, in revised form, that opus is available as the hardbound **A Wealth of Fable: An Informal History of Science Fiction Fandom in the 1950s.**

If you were active in the fandom of the time, this is surely a must-have. If you are fascinated by the history of the field and of the people who have made and loved it, you've got to have

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it. It covers fanzines and cons, tempests and teapots, pranks and hoaxes, legends and monuments, heroes and hooligans, fans and pros and the ones that became the other. There are photos of dozens of folks, including the youthful Robert Silverberg, Algis Budrys, Harlan Ellison, Marion Zimmer Bradley, Arthur C. Clarke, Robert Bloch, F. M. Busby, Greg Benford and his brother Jim, and many more. The only thing missing—except on the dust jacket—is a broad sampling of the cartoons that have traditionally decorated fanzines.

On the other hand, if you are more interested in science fiction itself than in the shenanigans that have long surrounded it, you won't miss this book a bit.

Sharyn McCrumb's **Zombies of the Gene Pool** reached me too late for a well-timed review, but since it pairs very neatly with Harry Warner's book, I'm going to tell you about it anyway.

McCrumb's background is precisely the world that Warner describes, the fandom of the fifties, and she mentions a number of people and events that he covers. Her center—that group of fans and wannabe pro SF writers known as the Lanthanides, the Tennessee Fan Farm they occupied for a time, the TVA dam that flooded farm, town, and valley—is fictitious, of course, as are the varied fates of the Lanthanides.

The tale begins on campus, where Jay Omega, electrical engineering professor and SF author, is waiting for his lady Marion, once a femfan, now an English prof. They are recruited to accompany Erik Giles to a reunion of the Lanthanides. The TVA is draining the lake to repair the dam, and there is a time capsule, a pickle jar full of ancient manuscripts, waiting to be retrieved. And Giles, it seems, was once one of the group, as well as the author of a classic novel.

McCrumb shows us the Lanthanides then and now. Kids who would rather talk about the future than make it. Adults who have sold out to Hollywood or academe. Adults who have remained stuck in the mimeo-cranking instar of their youth, or who have committed suicide or gone mad or—like Pat Malone—died after publishing a vicious rant on just how childish fandom was.

Or is Pat Malone dead after all? The group has gathered on the edge of the drained lake for cocktails, and suddenly who should walk into the room but Pat himself, in the flesh, as abrasive as ever. And then he is dead, murdered. It is up to Jay Omega to solve the case, just as it was in McCrumb's earlier *Bimbos of the Death Sun.*

The mystery is not terribly complex, subtle, or difficult. McCrumb's thrust is a critique of fandom, of people who refuse to grow up and embrace the real world, of people who grow sour without ever realizing what might have been or how they might have found a happier path. Not surprisingly, some fans have taken considerable umbrage. On the other hand, Warner makes it very clear that even McCrumb's most vicious jabs are not entirely unjustified.

* * *

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Over the past few years, Robert Frazier and Bruce Boston have been publishing in various magazines a series of "mutant rain forest" poems that have individually attracted a good deal of attention. Now those poems are available as a small book, **Chronicles of the Mutant Rain Forest**, and it is fair to say that when they are viewed together, in sequence, they are even more impressive.

Frazier and Boston begin by positing a flood of radioactivity released upon the Amazon area, perhaps by war. The immediate result is a storm of mutation and the appearance of new and marvelous life forms in the jungle, which soon begins to reclaim its own from its human despoilers. When people venture into it, they find strange diseases, strange beings, stranger states of mind, which as our poets chronicle them all in glimpses of strange history prove as communicable as measles.

The poets have a tendency to use unnecessarily esoteric language at times, but don't let that stop you. Boston and Frazier are remarkably erudite fellows, and their words and images are all well chosen and evocative. This is an impressive contribution to the poetic art.

BOOKS ON DISK

The latest word on desktop publishing is that you can now find it on the big computer information services, such as GEnie: "GEnieLamp is five separate online magazines that bring you the latest news, product reviews, bulletin board and library highlights from the [computer-related] RoundTables . . . released on the 1st of every month. . . . Find the future here and now in the GEnieLamp Online Library . . . publish and distribute your bookette here . . . fill the spaces in your next newsletter . . . with articles that you can reprint . . ." and so on.

Another interesting development is the "Library of the Future," created by Brad Templeton's ClariNet Communications Corporation (P. O. Box 1479, Cupertino, CA 95015-1479) and planned to be available in 1993. The idea is "all you can read" for about five bucks a month—one low fee gives you unlimited access to previously published (that is, professional level) short fiction and nonfiction in electronic form. You access the Library with your computer and modem via information services such as GEnie and CompuServe. If you don't like to read from your computer screen, you can print the material on paper.

Still another interesting development comes from Ai Squared (P. O. Box 669, Manchester Center, VT 05255-0669), which wrote me recently to say, "We are the developers of ZOOMTEXT (tm), a generic screen magnifier for the visually impaired. We are currently exploring development of a reading package" to distribute with the software.

Looks to me like Ai Squared and ClariNet could go together about as well as pepperoni and cheese. ■

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BRASS TACKS

Dear Mr. Schmidt (or Mr. Stine):

I am an enthusiastic supporter of space exploration and space industrialization. Nevertheless, I feel the need to challenge some of the conclusions in your October '92 column, "Polluting the Universe."

What bothers me most is your penultimate statement: "Space is so big that we couldn't possibly pollute it in more time than the human race has been around." It's a refrain that our ancestors uttered in contexts that now seem absurdly shortsighted. "The forests will last forever," said the lumberjacks of the last century. Resources are only endless until we find an efficient way to exploit them, then exponential growth takes over, making short work of what was once plentiful. The same doesn't necessarily apply to the pollution of space, but if the lessons of history mean anything, we should think carefully before uttering such statements.

I also don't have your faith in technological progress as a means of waste reduction. Like you, I am a professional journalist and author who works on a word processor. But when I recently completed a 500-page manuscript, I generated far more paper than I ever would have the old-fashioned way because I dumped hard copies to the printer at regular intervals along the way. I did so because it was easy and I don't care to trust a year's work solely to electronic media. Then I circulated photocopies to lots of people for comment. Far from saving paper, computers and photocopiers use up reams of it.

Furthermore, a couple of your Earth-bound pollution examples are too sanguine. Urban air pollution can be easily detected much further than 50 miles from its source. You say you live in Arizona. Next time you visit the Grand Canyon, ask the rangers what has happened to the air quality. It isn't the make-your-eyes-water smog you'll find in Phoenix during an inversion, but it is air pollution, sometimes reducing visibility enough to make the canyon hazy. And it's drifting in from LA, hundreds of miles away.

Similarly, you say that rendering this planet uninhabitable would require technology far beyond anything we have today, except perhaps global thermonuclear war. This is probably correct. But there is a big difference between "uninhabitable" and "unpleasant." We could argue endlessly over the details, but we already have plenty of ways to significantly change

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ecological balances, with unpredictable but probably negative consequences. Examples are global deforestation, massive coal burning bioaccumulating toxins, repeated leaks from nuclear reactors or waste repositories.

If an environment is pristine enough to begin with it doesn't take much to produce noticeable degradation.

An examination of space pollution, therefore, should begin with the question: What does it mean to "pollute" space? As a working definition, your biological model of pollution as the creation of more, or different, waste than the immediate environment can recycle or reprocess seems a good one. In space, of course, this means virtually everything.

Are footprints on the Moon a form of aesthetic "pollution"? It won't take a working lunar colony long to track up the surface enough to look a lot different than it does today. Untrammeled wilderness on the Moon will be a use-it-once-and-lose-it commodity unless *everyone* stays on the trails!

Off planet, pollution will probably come in two categories. Particulates (which would include everything from a space worker's dropped hammer to grains of dust) and gases (or plasmas). Particulates are going to be a real problem. They'll hang around Earth orbit or collect in the stable Lagrangians as navigational hazards. Gases are a different issue. They'll disperse and (I'm only considering the Earth/Moon system) be blown away by the solar wind. The question is, how much is "pollution"? The answer would seem to lie at a many orders of magnitude lower density than it does for the Earth's atmosphere or waters. I suggest that we should consider the interplanetary medium "polluted" if human additions to it (at least those that are different in composition from the medium itself) constitute the same fraction of the preexisting interstellar medium as Earth-bound pollutants do of polluted air or water.

That means parts-per-million or -billion additions to something that is very tenuous to begin with, though we're also talking about the enormous volumes of space discussed in your article. How much mass would it take to pollute the interplanetary medium inside the lunar orbit by 1 part per million? I expect it's a lot; and that a lot of it blows away on the solar wind pretty quickly. But this would seem to be a much better approach than the look-how-long-it-took-us-to-pollute-the-Earth volume comparisons in your column. And it may reduce the result to something which *could* happen in the foreseeable future.

This is not to say that such "pollution" necessarily matters. But it might. Maybe it would foul up industrial processes or force some industries into deeper space. Maybe Earth/Moon system astronomers using ultra-sensitive spectroscopic methodologies of the future will be less than pleased with even trace amounts of weirdly absorbing gasses from space factories.

Maybe these gasses will merely give spectral signatures to the solar

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wind, conveying the message to waiting extraterrestrials that Sol finally has a permanent space-faring intelligence. But it will still have been an intelligence that did the "impossible" and polluted the near Earth interplanetary environment.

RICHARD A. LOVETT, Ph.D., J. D.
Portland, OR

Dear Stan:

G. Harry Stine's AV on "Polluting the Universe" overlooks a couple of points on polluting the galactic environment. Radio astronomers have identified quite a few unpleasant components in various nebulae, including methyl alcohol, hydrogen cyanide, and carbon monoxide. He's right when he says that we can't make any serious increase in the galactic smog; it's already pretty dirty out there.

More importantly, the Galaxy recycles its own wastes. Think of the Galaxy as a closed ecology, with electromagnetic and gravitational forces, stellar winds, light pressure and shockwaves from supernovae stirring up the material. Then consider what happens when a star goes supernova. It leaves behind a nebula, and after a while (one "while" being a highly precise term equal to 1.1 zillion years) the material in the nebula becomes the ingredients in one or more new solar systems (this, of course, is where every terrestrial atom heavier than helium came from). Any wastes outgassed by an inefficient space factory will be blown into interstellar space by the solar wind, and after a while these wastes will end up as part of something like the Orion Nebula, to condense into new stars and planets.

Pulling tongue out of cheek, the real problem at the heart of "Polluting the Universe" is the definition of "pollution." Some people seem to define it as anything, anything at all, made by human beings, while other people seem to think that pollution is a complete non-issue. I've seen other definitions that stray from the usual meaning of "unwanted by-products of a man-made process," usually because someone has an economic or political interest in changing the definition. I don't recall offhand if Harry Stine has done a column on *how to define pollution*; if he hasn't, it might make an interesting topic.

BILL THOMPSON

Dear Mr. Schmidt:

I would like to present an alternative approach to your editorial on "Ex Post Facto Morality" which condemned Columbus "bashing" as a possible threat to future exploration. In insisting on judging Columbus by the mores of his own era, I believe you are resisting another evolutionary force—the evolution of cultural standards. As a science fiction editor, you must be aware that the evolution of ideas and morals is a major force for social and political and even technological progress.

Columbus "bashing" is just such an evolution—a turning away from a simplistic celebration to a much more complex commemoration. This is history in the making, the process of evolution before our eyes. Colum-

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bus "bashing" demands that the commemoration of Columbus's bold explorations also recognize all the historic consequences of his accomplishments. Instead of merely extolling the heroic boldness and vision of one navigator (and the equally courageous members of his unnamed, unremembered crew), we are being asked also to recognize and mourn the tragic deaths of millions of innocent people and the decimation of their culture.

The issue is not justice or injustice to a man long dead, but what lessons does the current generation find in history—how does our understanding evolve? Of course it is uncomfortable: Columbus as anti-hero. But this is exactly the kind of change that can lead us to "learn from history and take pains to do it right next time."

ANNA WILLMAN
650 Callahan Road
Roseburg, Oregon 97470

Far from "resisting" the evolutionary force you speak of, my main point was the importance of people's recognizing it! And that includes recognizing the difference between saying we *shouldn't do things Columbus did, and saying* he *shouldn't have!*

Dear Sir:

Those who worry about the morals of Christopher Columbus should turn their attention to today, when real immorality, repudiation of known moral principles, is tearing this society apart.

By morality I mean the principles of behavior which both reason and experience have shown are necessary for a happy and prosperous society. I refer to those rules of conduct known generally as the "Judeo-Christian ethic."

It is popular today to blame much of our lawlessness on poverty, that is nonsense. During the "Great Depression" we had real poverty, but comparatively little crime, because this rule of behavior, although imperfectly observed, was still the ideal. Then it was scandalous to bear a child out of wedlock. Now our government rewards them with a welfare check, free medical care, often free housing. Small wonder we get more of them. Yet the real evil is not the expense, but that they have borne several generations of children who have no concept of the family, of responsibility, of morals. This is the reason for the poverty and the inner city gangs, etc.

For the sake of money, our media pours a stream of filth into society —pushing drugs, violence, sex and perversion—and contempt for morals and authority, corrupting the minds of our young people. Our government is busy robbing one group to buy the votes of another (When A robs B to give it to C, it is not charity but robbery. All our government "aid" programs reward indolence, dishonesty, carelessness, and punish hard work, honesty and dedication.) One species of sexual perversion has inflicted a deadly virus upon society, which is still spread by immoral behavior (sexual promiscuity, both homo- and heterosexual). The way it is spread is known, therefore the way to stop it is known, but it is not fash-

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ionable to say this aloud. Instead, AIDS has become the first politically protected communicable disease.

Our forefathers knew that power corrupted, therefore they were at pains to set up a government of limited power. Corrupt politicians have perverted the Constitution to set up a government of virtually unlimited power, which makes corruption not only possible but inevitable.

Truly, those who worry about the morals of such as Columbus should turn their attention to more recent events.

JOHN R. LEDBETTER JR.

Rogersville, AL

Dear Stanley Schmidt:

I enjoyed Julia Ecklar's ecological "Ice Nights," and L.A. Taylor's psychological "Waste Not, Want Not," in the October *Analog*. But Sean McMullen's historical "A Greater Vision" had its clever gimmick marred by historical impossibility.

Columbus's sailors knew perfectly well that the world was round. So did every other culture that sent sailors off in tall-masted ships. Watching ships fall off the edge of horizon and come back up over it every time anyone went sailing tended to convince them that the world was round. Moreover, the ancient Greeks had measured the curvature and come up with an accurate diameter centuries earlier. Every educated person knew the world was round and knew how large it was.

Columbus was not a visionary, bringing a new and more accurate image of the globe. He was an optimist who thought that the globe was smaller than it was, so that the distance from Spain to India would be shorter going west than going east, and who thought that there would be no continents like Africa to slow the passage. He was wrong on both counts, but he was lucky and hit land before he ran out of his inadequate supplies. If he'd been turned back, however "miraculously," others would have gone on trying. The money in the spice trade was a potent motivator.

RUTH BERMAN

Minneapolis, MN

Dear Dr. Schmidt,

I enjoyed Martyn Fogg's article on habitable planets a great deal, especially the vision of hundreds and thousands of them just waiting for us to get to work (Oct. '92). In this informative and interesting article there is, however, one error that, as a biologist, I feel compelled to write about.

The time when Earth acquired a one-fifth oxygen atmosphere is said in the article to be about 600 million years ago in the late Precambrian. Actually, it was about two and a half billion years ago (see, for instance, Raven and Johnson, "Biology," 1989, or any other good college level basic biology text). The oceans at this time underwent a tremendous bloom of cyanobacteria, more commonly known as bluegreen algae, though they are not actually like any other algae. The reason for this bloom is not known for certain, but cyanobacteria photosynthesize and give off oxygen

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like green plants, so the result of the bloom is very evident. In the pre-oxygenated oceans there were considerable quantities of dissolved iron, but after the bloom the iron oxidized leaving great beds of rusty ores that mark the time of the event. About one and a half billion years ago the first unicellular organisms with nuclei are assumed to have evolved, probably from a symbiosis between two very different kinds of bacteria (none of which have any internal structures such as nuclei). The timing of this event is unlikely ever to be known for sure, since such delicate single cells may never have formed fossils. Finally, sometime in the later Precambrian, multicellular organisms arose, and by the time the Cambrian rolled around, 500 million years ago, there were sponges and jellyfish and simple worms and seaweeds. Telescoping two billion years of evolution into one hundred million years would be a major feat.

Given the subject of the article, merely getting the timing of oxygenation on Earth wrong does not change any of Martyn Fogg's points. One interesting tangent is that given the large number of useful planets likely to exist, assuming his simulation reflects reality, there may also be a large number with life developing on them, if some current theories are correct. The heavy bombardment of meteorites early in Earth's history is likely to have included at least some big enough to wipe out any life that did exist to remelt the whole surface. The fact that life arose so soon after the major bombardment stopped (as evidenced by geologic layers with relative isotopic abundances indicative of life), leads some people to speculate that life may develop rather easily when liquid water is present and free oxygen is absent. Life may have arisen several times, in between meteor strikes, until finally the meteors no longer struck. Finding any sort of traces of life on Mars would tend to support this theory strongly, and, in my view, is the most compelling reason for exploring Mars. (Though not finding it would not disprove the theory, given how inhospitable Mars has always been.) And if life does arise easily, then almost every one of the thousands of worlds Martyn Fogg envisions may have some weird and wonderful alien cells on it, perhaps even grouped into alien beings.

I certainly hope to see the day when Very Long Baseline Interferometry on the far side of the Moon shows us planets to try for, and we start preparing the scoutships to go there!

MIA MOLVRAY

New Orleans, LA

Dear Stan,

Not to take anything away from David Goines's great gag in the October issue ("On The Inefficiency of Beauty Contests..."), but it should be pointed out that the notion of using the "helen" as a unit of feminine beauty, one helen being equal to the degree of beauty required to launch one thousand ships, goes back at least to 1975.

I first encountered it in Bill Sherk's 1981 book, *More Brave New Worlds*

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(Doubleday), where a "millihelen" is defined as follows:

> Is there a woman living today whose face would launch a thousand ships? That's difficult to say—but if 500 ships sail off to rescue a damsel in distress, her beauty would measure half a Helen. And if only a single leaky rowboat puts out to sea? That's when we speak of a *millihelen.*

Sherk attributes the word to an unknown coiner, but notes that it appears on page 457 of the 1975 *Guiness Book of World Records.*

Just to set the record straight.

CHARLES ARDAI ■

IN TIMES TO COME

Next month we offer our July double issue, leading off with *The Man Who Stayed Behind,* a complete novel by Paul Ash. You may remember O.M. Rivers from an earlier story or two, but this one looks at an earlier stage of his career—and at a question so basic it's seldom asked: if you had telepathy, what could you use it for? If you think the answer is obvious, be sure to read the story!

The rest of the fiction line-up spans the entire range of lengths and subject matter: from novellas to short stories, from the profound to the whimsical, from past to near-present to far future. G. David Nordley's "Into the Miranda Rift" is an exotic adventure that in some respects may remind you of last year's very popular "Poles Apart," yet in others is wildly different. Spider Robinson returns to Mary's Place with "The End of the Painbow"; Ian Stewart stretches your mind *way* out in "The Ape That Ate the Universe," Thomas Donaldson does the same thing, only different, in another of his speculative fact articles, "The Holes of Space-Time."

And, of course, we'll have all the features, plus the Analytical Laboratory results for 1992—the fruits of *your* voting—and perhaps a special feature or two.

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UPCOMING EVENTS Anthony Lewis

4-6 June

AD ASTRA 13 (Toronto regional SF conference) at Sheraton Toronto East Hotel, Toronto, Ont. Pro Author Guest of Honour: Anne McCaffrey; Special Author Guest of Honour: David Duncan; Artist Guest of Honour: Robin Wood. Registration—C$26 (US$22) until 15 May, C$32 at the door (includes GST). Info: Ad Astra 13, PO Box 7276, Station A, Toronto, Ontario CANADA M5W 1X9.

4-6 June

CONJURATION/DeepSouthCon 31 (southern regional SF conference) at Executive Inn East/Airport, Louisville, Ky. Guests of Honor: Emma Bull & Will Shetterly; Artist Guest of Honor: Dawn Wilson; Fan Guest of Honor: Genny Dazzo; TM: Andrew J. Offutt. Registration—$20 until 3 May, $25 thereafter, $35 at the door. Info: Conjuration/DSC '93, Box 5231, Louisville KY 40255.

18-20 June

DIVERSICON (discussion-oriented SF conference) at Seville Plaza Hotel, Bloomington, Minn. Guests: Eleanor Arnason, A. C. Crispin, Ruth Berman. Registration: $20 until 1 May, $25 at the door. Info: Eric M. Heideman, General Committee Head, PO Box 8036, Lake Street Station, Minneapolis MN 55408.

1-5 July

WESTERCON 46 (West Coast SF conference) at Red Lion Hotel, Bellevue, Wash. Guest of Honor: Greg Bear; Artist Guest of Honor: George Barr; Fan Guests of Honor: F. M. Busby, Elinor Busby, Wally Weber, Wally Gonser; TM—George Alec Effinger. Info: PO Box 24292, Seattle WA 98124. (206) 742-8943.

2-6 September

CONFRANCISCO (51st World Science Fiction Convention) at Parc 55. ANA Hotels, Moskone Centre, San Francisco, Calif. Guest of Honor—Larry Niven; Artist Guest of Honor—Alicia Austin; Fan Guests of Honor—Tom Digby and jan howard finder; MC—Guy Gavriel Kay. Registration—$110 adult/$30 child until 31 March 1993, $125 adult/$30 child until 16 July 1993. Supporting—$25. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: 712 Bancroft Rd, #1993, Walnut Creek CA 94598. (510) 945-1993. CompuServe 72377,3623.

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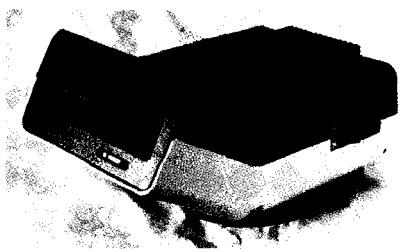

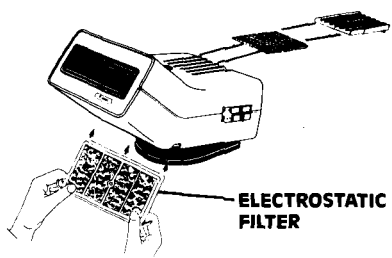

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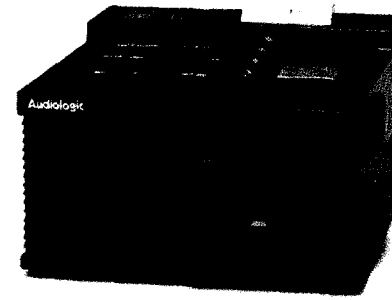

Is noise pollution interfering with your ability to get a good night's sleep? If so, then the Sound Sleeper by Audiologic is the clock radio of your dreams. Sound Sleeper combines a state of the art AM/FM cassette clock radio with the benefits of natural sound conditioning. Sound Sleeper lets you fall asleep to the sounds of ocean surf, rushing waterfalls and/or rainfall with the flip of a switch. After a relaxing night's sleep, wake up with a buzzer or music from the radio or cassette. So why have an ordinary clock radio when you can have the cassette clock radio that not only wakes you up but also lulls you to sleep! **$89.98** ($5.50) #A2000.

TO ORDER: Send check with item number for total amounts, plus shipping & handling shown in ( ) payable to **MAIL ORDER MALL** Dept. 063 AN; P.O.Box 3006, Lakewood, N.J. 08701, or call TOLL FREE **1-800-722-9999**. NJ residents add 7% sales tax. We honor MasterCard, Visa, and American Express. Sorry, no Canadian, foreign, or C.O.D. orders. Satisfaction Guaranteed. 30 day money back guarantee for exchange or refund. Allow 30 days for delivery.

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